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EXPERIMENTAL VALIDATION OF THE ANTENNA PATTERN DISTORTION COMPU--ETC(U)

APR 80 J PERINI, H MOSES F30602-75-C-0121

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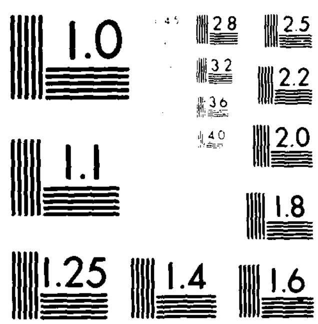
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LEVEL II

1842 EEG/EEITR TR 80-5

TECHNICAL REPORT

EXPERIMENTAL VALIDATION OF THE ANTENNA PATTERN DISTORTION COMPUTER PROGRAM - DISTORT (UHF ANTENNAS)

TRACALS & ELECTRONICS SYSTEMS BRANCH
SCOTT AIR FORCE BASE, ILLINOIS 62225

30 May 1980

1842 ELECTRONICS ENGINEERING GROUP

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1842 EEG
Scott AFB, IL
(8/638-2658)
to Marvin Horschman,
Proj. Monitor Engr.
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This report describes the procedures and the experimental measurements carried out to validate the Antenna Pattersn Distortion Computer Program (DISTORT) for the AT-197/GR and AS-1097/GR UHF antennas. The report also covers the validation of the reflection coefficient formulation for imperfect earth.

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This report has been reviewed and is approved for publication and distribution.

Gerald T. Harris

GERALD T. HARRIS
1842 EEG/EEI
Chief, Electronics/Base Systems Engineering Division

Amos J. Hardy

AMOS J. HARDY
1842 EEG/EEIT
Chief, TRACALS/Electronics Systems Branch

Marvin Hirschman

MARVIN HIRSCHMAN
1842 EEG/EEITR
Project Monitor Engineer

ABSTRACT

This report describes the procedures and the experimental measurements carried out to validate the Antenna Pattern Distortion Computer Program (DISTORT) for the AT-197/GR and AS-1097/GR UHF antennas. The report also covers the validation of the reflection coefficient formulation for imperfect earth.

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EXPERIMENTAL VALIDATION OF THE ANTENNA PATTERN DISTORTION COMPUTER PROGRAM - DISTORT (UHF ANTENNA AT-197/GR and AS-1097/GR)

1.0 INTRODUCTION.

1.1 The Antenna Pattern Distortion Computer Program (DISTORT) was written at the request of AFCC to evaluate the distortion on the radiation pattern of communication antennas when mounted in close proximity to each other, such as in the communication towers of many Air Force installations.

1.2 In a previous report[1], the computer program was validated for the VHF AS-1181/GR Antenna. In this report, the validation for the UHF Antennas AT-197/GR and AS-1097/GR is carried out.

2.0 MEASUREMENT EQUIPMENT AND SETUP.

2.1 The measurements were performed in the large anechoic chamber at the Rome Air Development Center, Building 3. Because the frequency range of the measurements (225-400 MHz) was somewhat below the minimum design frequency of the chamber, some preliminary measurements were performed to verify how well the chamber behaved at these frequencies.

2.2 The measurement setup is shown in Figure 1 and is self explanatory. Early in the measurements, it was decided to use clusters of two and of three antennas with separations between them of 1, 1.5, and 2 meters. Note that 1 m corresponds to one wavelength at 300 MHz.

2.3 The theory[2] states that the radiation pattern of a transmitting antenna can be measured by using the antenna in the receiving mode if the antenna is illuminated by a plane wave. This condition can be achieved if the illuminating antenna is far enough from the receiving one such that[2]

$$D > 2\frac{A^2}{\lambda}$$

where

D - is the distance between the illuminating and the receiving antennas.

A - is the maximum receiving aperture.

λ - is the wavelength.

2.4 In the case of two antennas, the maximum distance between them used in the measurements was 2 m. Therefore, for f = 400 MHz, λ = 0.75 m, A = 2 m, results in D = 10.67 m.

---

[1] Perini, J. and Moses H., "Experimental Validation of the Antenna Pattern Distortion Computer Program (VHF Antenna)," RADC-TR-77-374, December 1977.

[2] Krauss, J.D., "Antennas". New York: McGraw-Hill

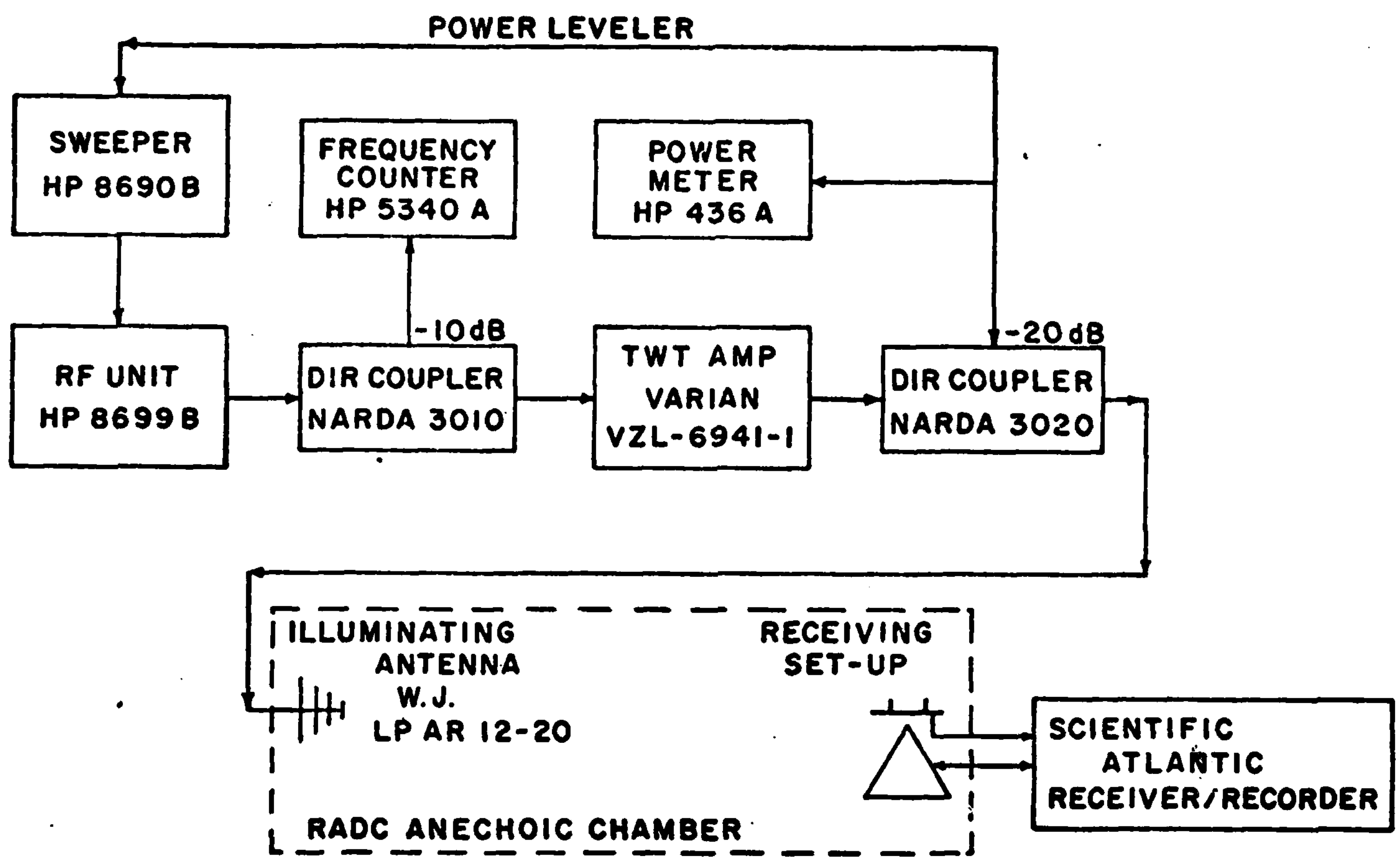


Figure 1. Measurement Setup

2.5 In the case of three antennas in the vertices of an equilateral triangle having 2 m on the side, still the maximum aperture is A = 2 m and therefore, D = 10.67 m for 400 MHz.

2.6 Measurements were always made at frequencies of 250, 325 and 400 MHz with apertures (antenna separations) of 1, 1.5 and 2 m. Table 1 shows the minimum distance D required for all of these combinations.

2.7 Since it was not always possible to position the illuminating antenna at a distance D more than 10.67 m due to the size of the chamber, this condition introduced minor errors in the measurement[2].

Table 1

Minimum Illuminating Antenna Distance $D = 2A^2/\lambda$ (m)

F(MHz)	(m)	A = 1m	A = 1.5m	A = 2m
250	1.20	1.67	3.75	6.67
325	0.92	2.17	4.89	8.70
400	0.75	2.67	6.00	10.67

3.0 AS-1097/GR MEASUREMENTS - TWO ANTENNAS.

3.1 Before any measurements were performed, a VSWR test was performed on each of the antennas to be tested using a network analyzer. The measurement was made with each antenna standing alone and away from any metalic obstruction. A typical plot is shown in Figure 2. All of the antennas used had surprisingly similar plots showing good quality control in manufacture.

3.2 Next, only one AS-1097/GR was mounted at the position where it would be located during the actual measurements (0.5, 0.75 and 1 m from the center of rotation), and a radiation pattern was recorded. Because the AS-1097/GR is an omnidirectional antenna, if the illuminating field was a plane wave, the recorded pattern should be a circle. Therefore, this is a verification of how well the theoretical conditions were met by the anechoic chamber. Figures 3 to 8 show the results of these measurements. Table II summarizes the maximum deviation (one-half of the difference between the maximum and minimum) from a perfect circle for each of these plots. In all of the measurements made for this setup, the illuminating antenna was at D = 9.75 m,

Table II

Maximum Deviation ($\pm$ db) from a Circle
for the two AS-1097/GR Setup

D = 9.75 m Separation	Frequency (MHz) 250	325	400
1.0 m	1	1	1.25
2.0 m	3	2.5	1.25

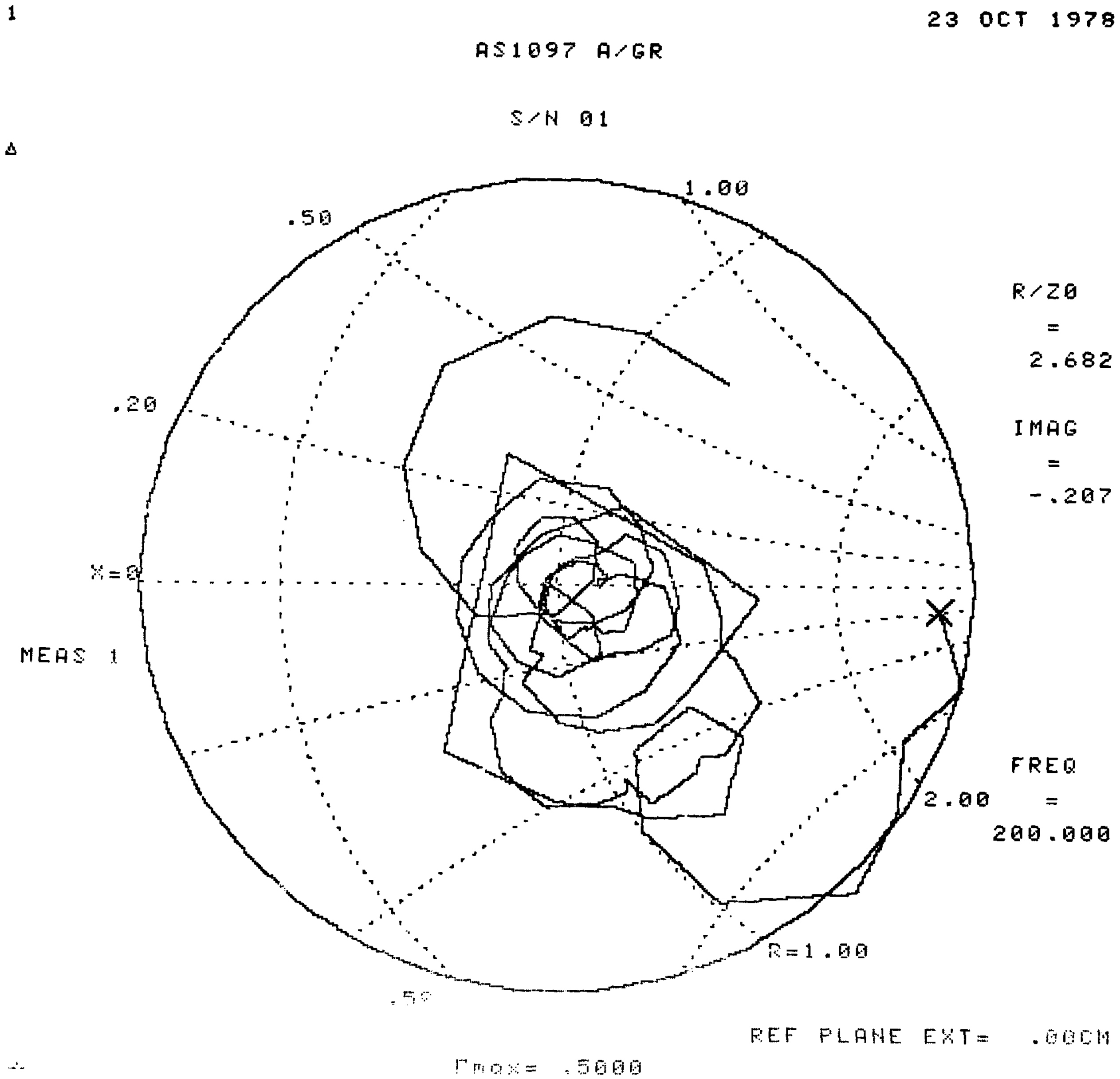


Figure 2. Typical VSWR Plot of an AS-1097/GR

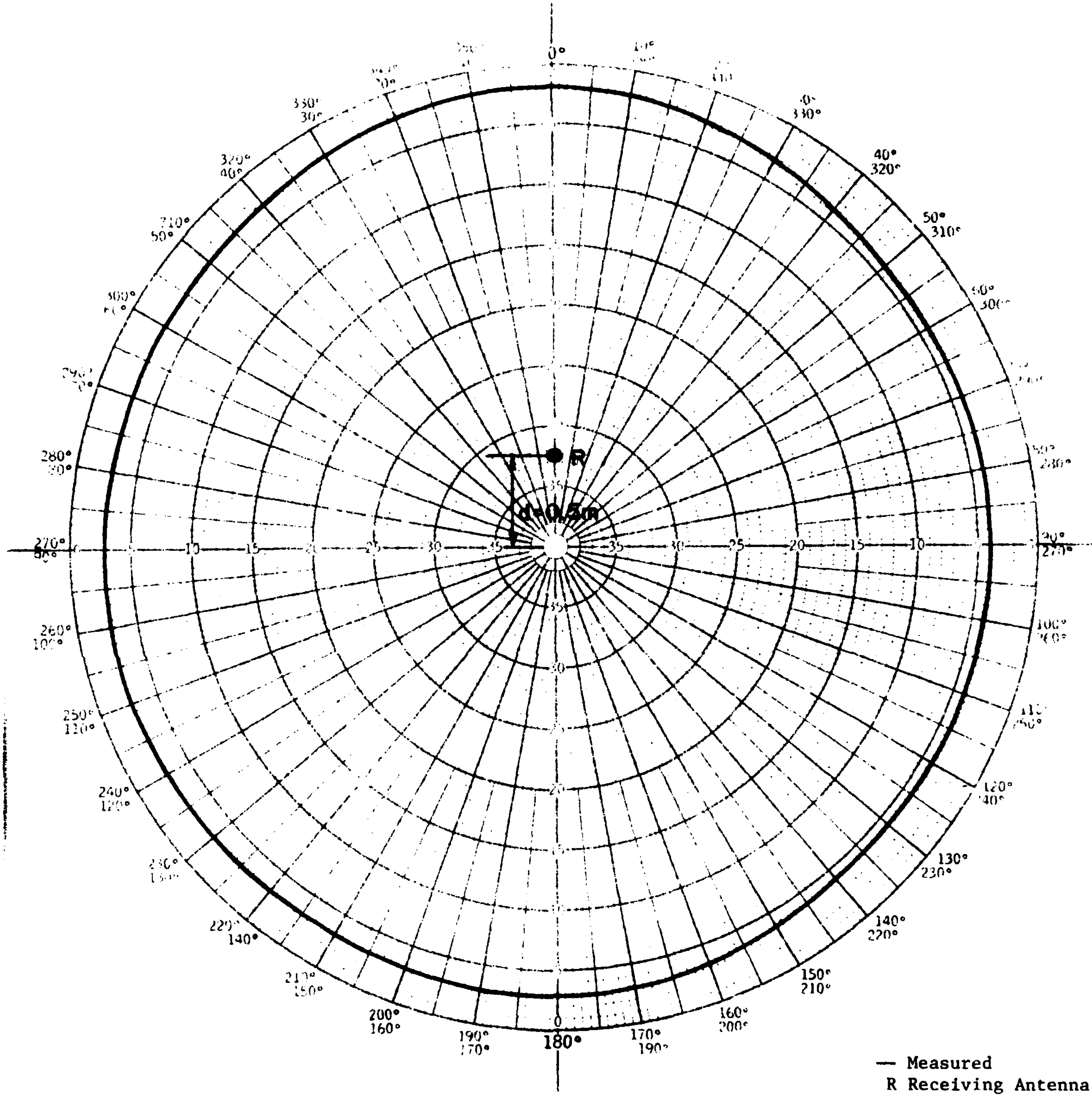


Figure 3. One AS-1097/GR, f = 250 MHz, d = 1 m for Two Antenna Setup, D = 9.75 m

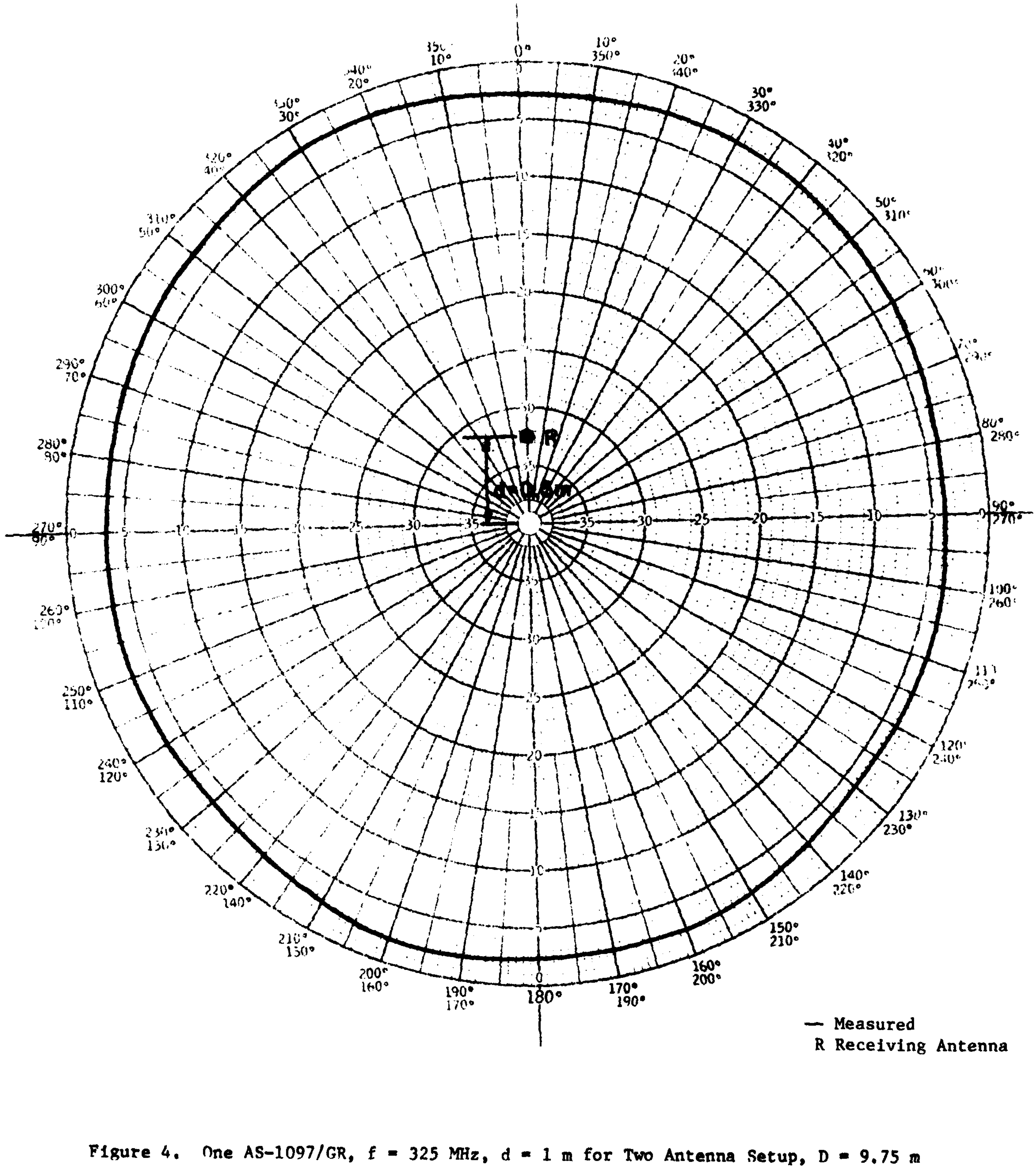


Figure 4. One AS-1097/GR, f = 325 MHz, d = 1 m for Two Antenna Setup, D = 9.75 m

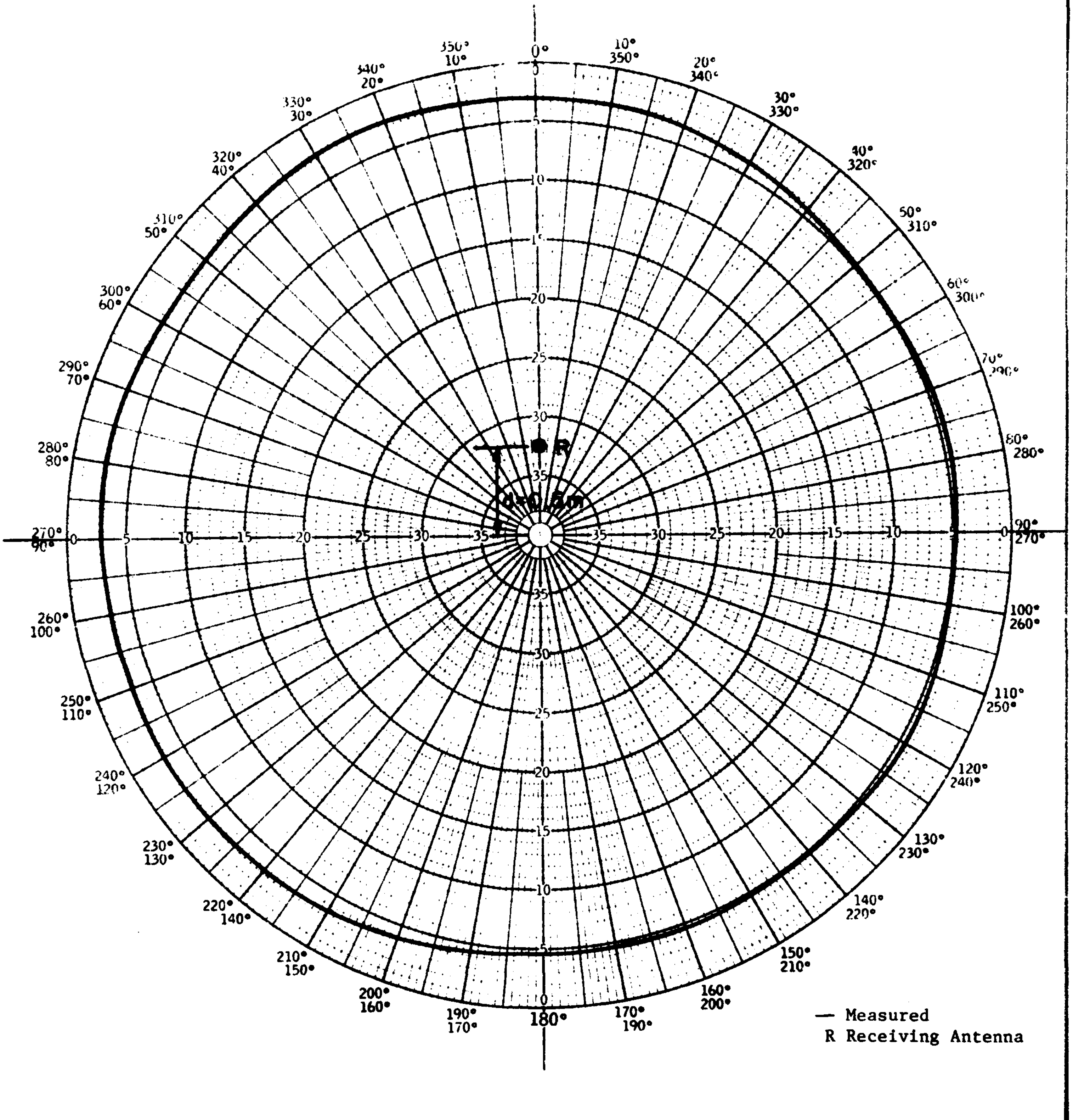


Figure 5. One AS-1097/GR, f = 400 MHz, d = 1 m for Two Antenna Setup, D = 9.75 m

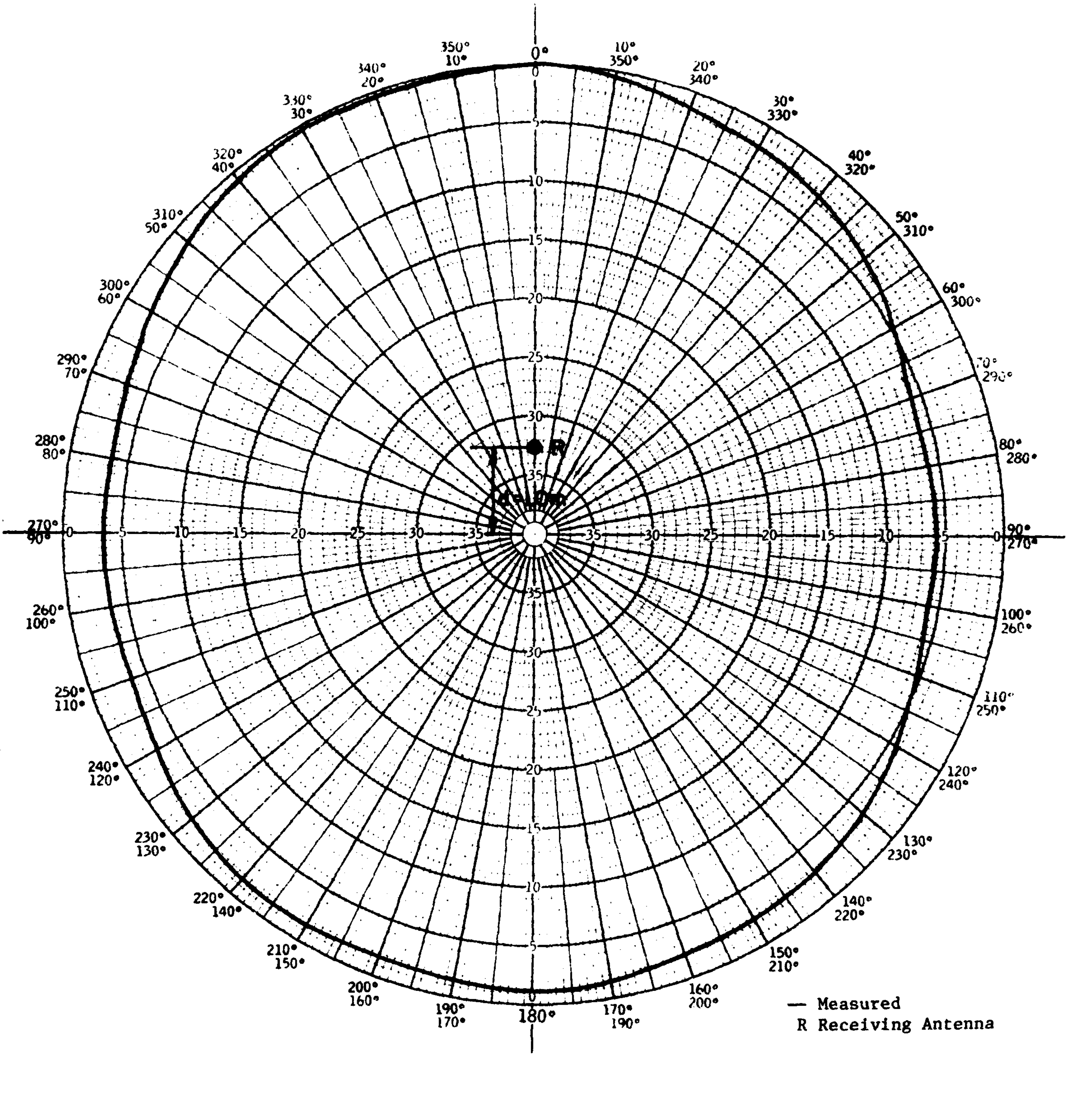


Figure 6. One AS 1097/GR, f = 250 MHz, d = 2 m for Two Antenna Setup, D = 9.75 m

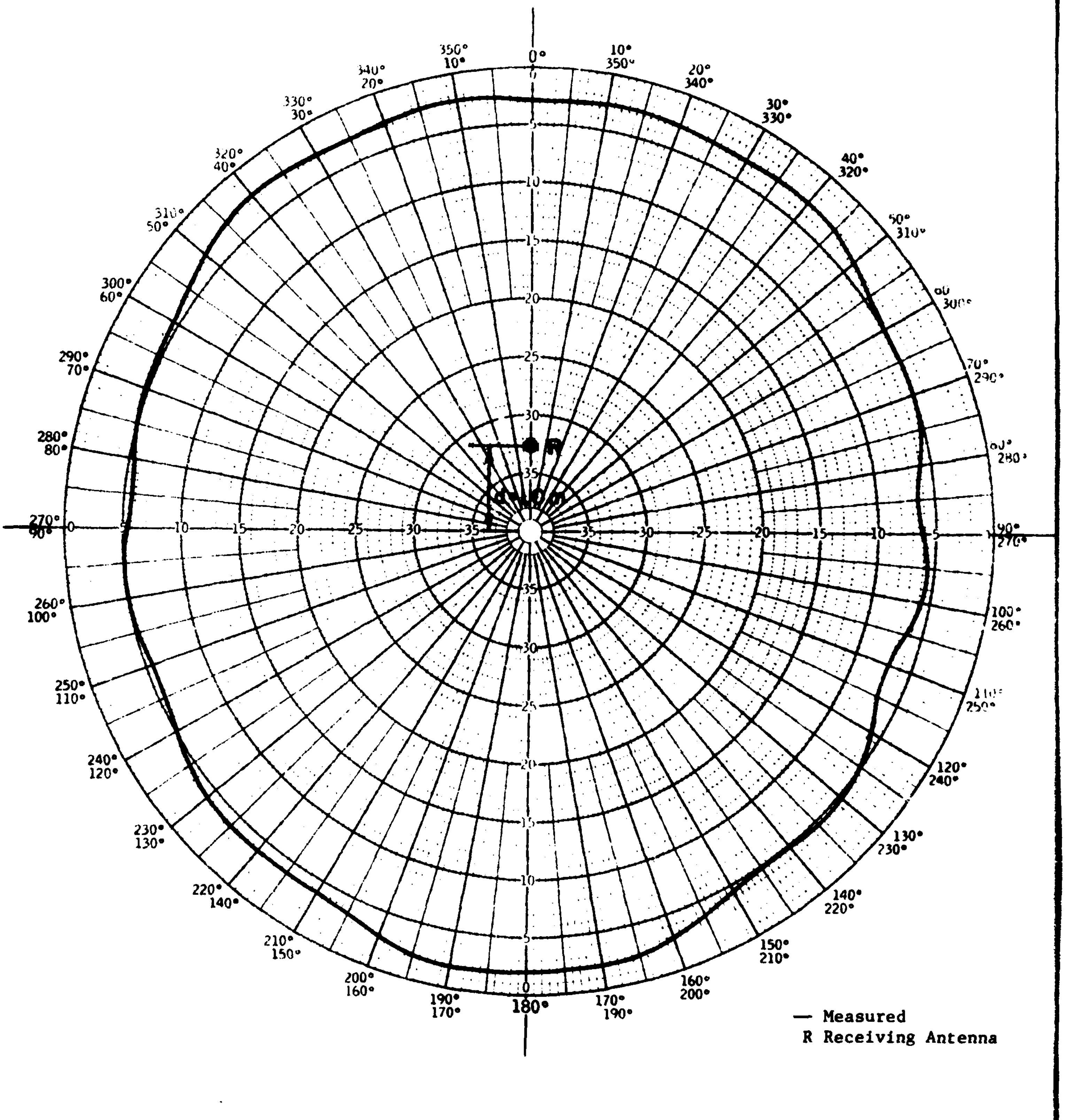


Figure 7. One AS=1097/GR, f = 325 MHz, d = 2 m for Two Antenna Setup, D = 9.75 m

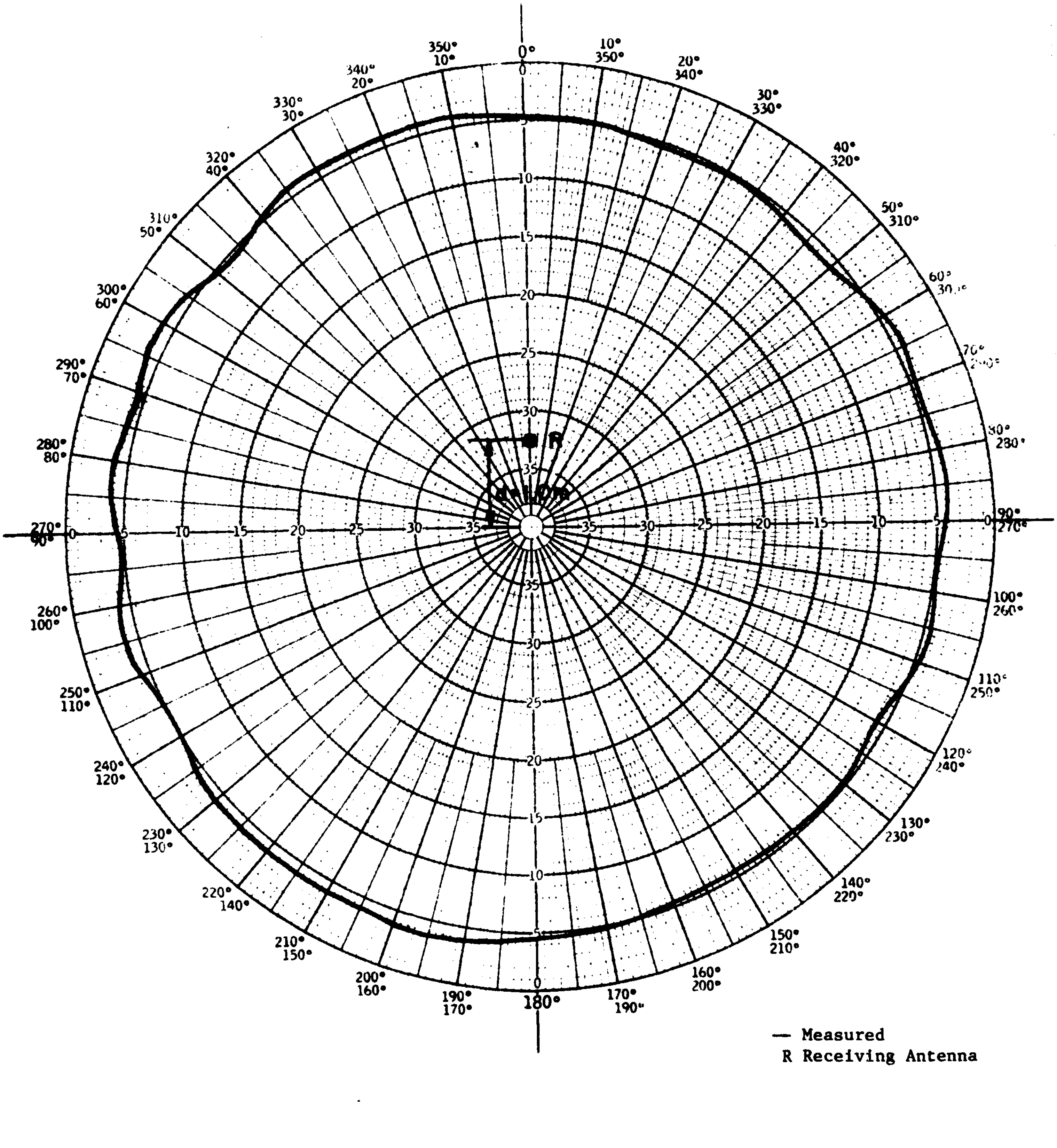


Figure 8. One AS-1097/GR, f = 400 MHz, d = 2 m for Two Antenna Setup, D = 9.75 m

3.3 This means that errors of up to the values on the table may be encountered in the measurements due to mutlipath reflections on the chamber. For example, a-20 dB reflection will produce a maximum of $\pm$1dB error in the measurement.

3.4 Next, two AS-1097/GR Antennas were positioned at 1, 1.5 and 2 m separation with one antenna terminated by a 50 ohm load and the pattern of the other recorded. The results are shown in Figures 9 to 17 with the receiving antenna indicated by a R. Using the DISTORT program, the corresponding patterns were calculated and their values are shown by the "x's" in the above figures. It is seen that the agreement is well within the expected accuracy of Table II. Observe that in most runs, as for example in Figure II, the measured pattern is not symmetrical around the 0-180° line as it should be; this is due to multipath reflections in the chamber which obviously are not symmetric.

4.0 AS-1097/GR MEASUREMENTS - THREE ANTENNAS.

4.1 Again, after the mounting structure to be used for the measurements of three AS-1097/GR Antennas was fabricated, a probing of the illuminating field (to see how close it was to a plane wave) was made by measuring the radiation pattern of only one antenna mounted at one of the vertices of the equilateral triangular support. Figure 18 shows a photograph of the anechoic chamber setup; Figures 19 to 27 show the measurements. It is seen that for the 2 m separation we are far from a plane wave illumination. This was the best that could be obtained by moving the illuminating antenna shown in Figure 28. The illuminating antenna for these measurements was at a distance D = 8.54 m. Table III summarizes the deviations from a plane wave (one-half of the difference between the maximum and minimum observed).

Table III
Maximum Deviation ($\pm$ dB) from Circle
for the Three AS-1097/GR Setup

D = 8.54 m Separation	Frequency (MHz) 250	325	400
1.0 m	1.5	2.0	1.25
1.5 m	2.0	2.5	1.5
2.0 m	3.5	2.75	2.5

4.2 Next, three AS-1097/GR Antennas were mounted on the equilateral triangular structure; two were terminated with a 50 ohm load and the pattern of the third one was recorded. Figures 29 to 37 show the results. The plot "x's" show the calculated values obtained using DISTORT. As shown, the errors are within the expected accuracy of Table III.

5.0 AT-197/GR MEASUREMENTS - TWO ANTENNAS.

5.1 The measurements for the AT-197/GR Antennas follow exactly the same procedure used for the AS-1097/GR Antennas. The input VSWR of each of the antennas used was measured with a network analyzer. A typical plot is shown in Figure 38. Again, they were strikingly similar.

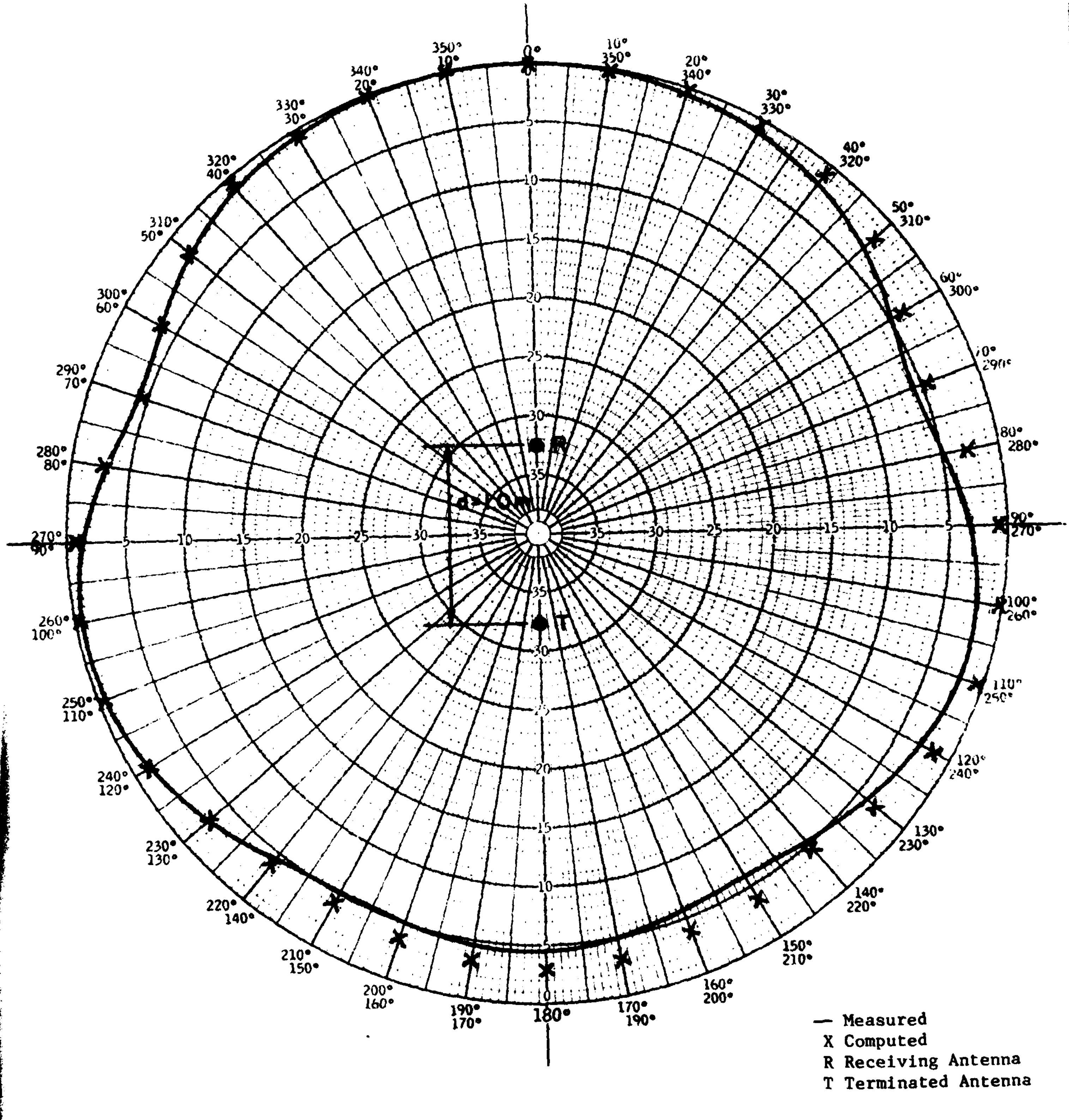


Figure 9. Two AS-1097/GR, f = 250 MHz, d = 1 m, D = 9.75 m

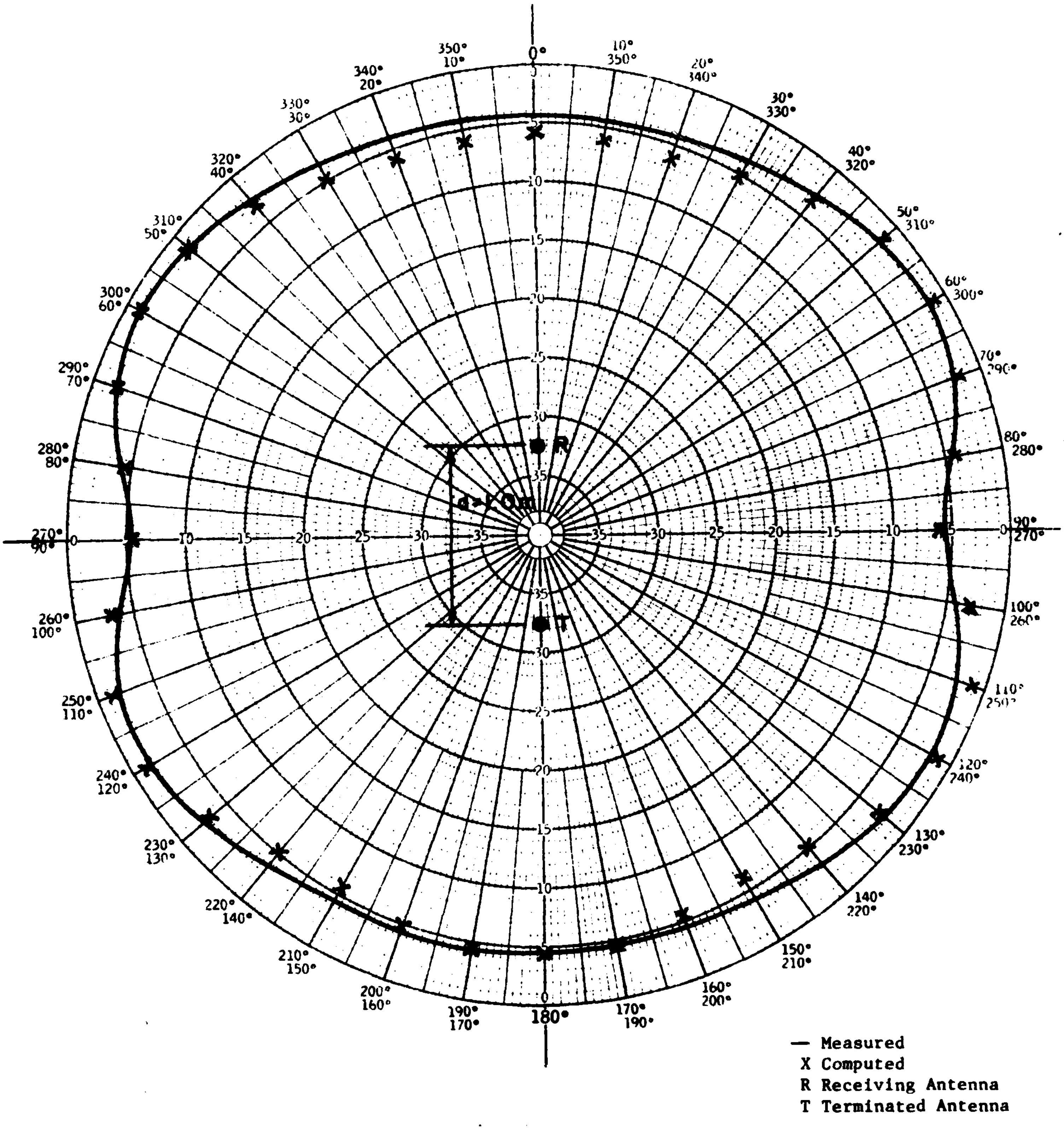


Figure 10. Two AS-1097/GR, f = 325 MHz, d = 1 m, D = 9.75 m

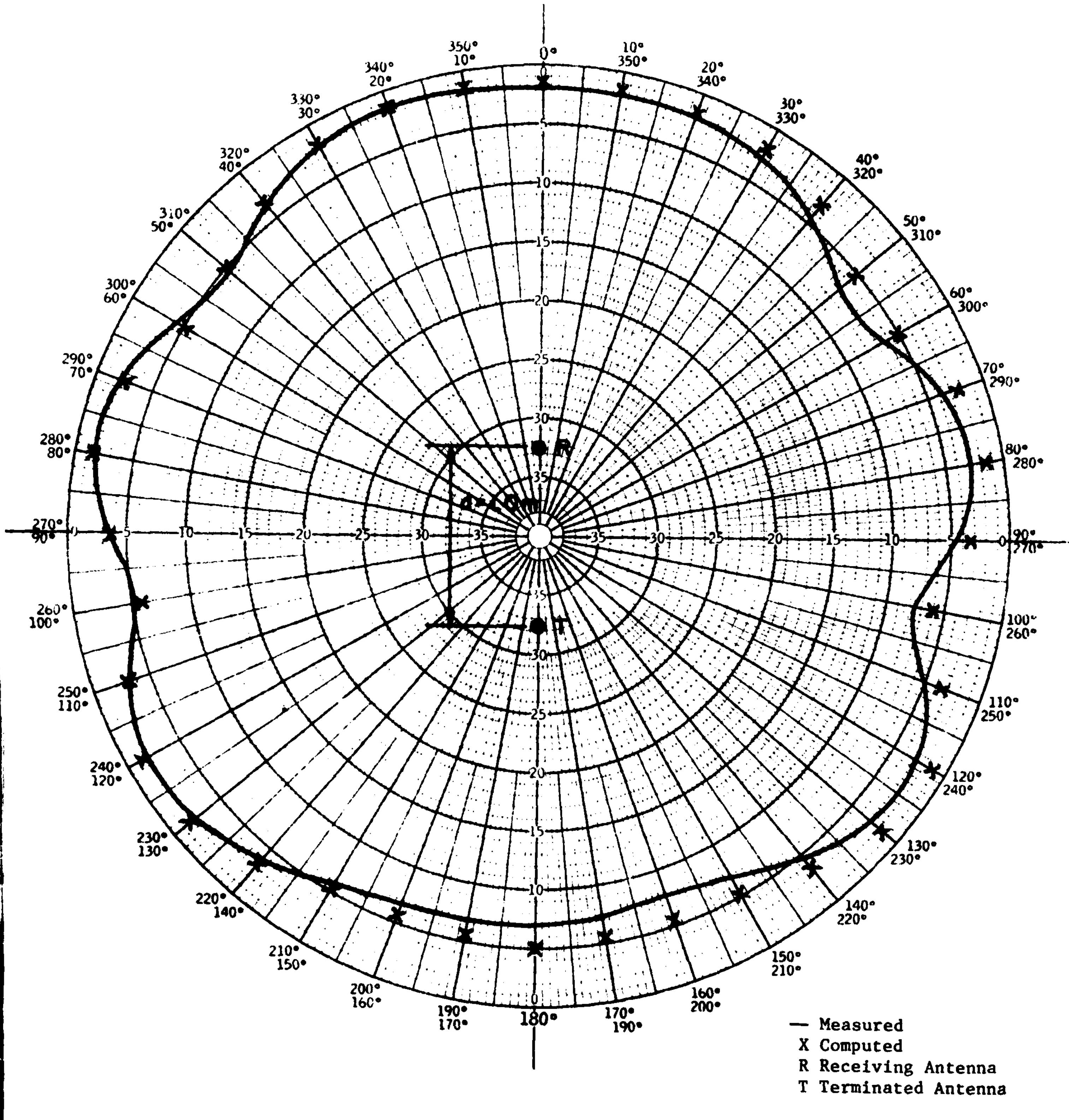


Figure 11. Two AS-1097/GR, f = 400 MHz, d = 1 m, D = 9.75 m

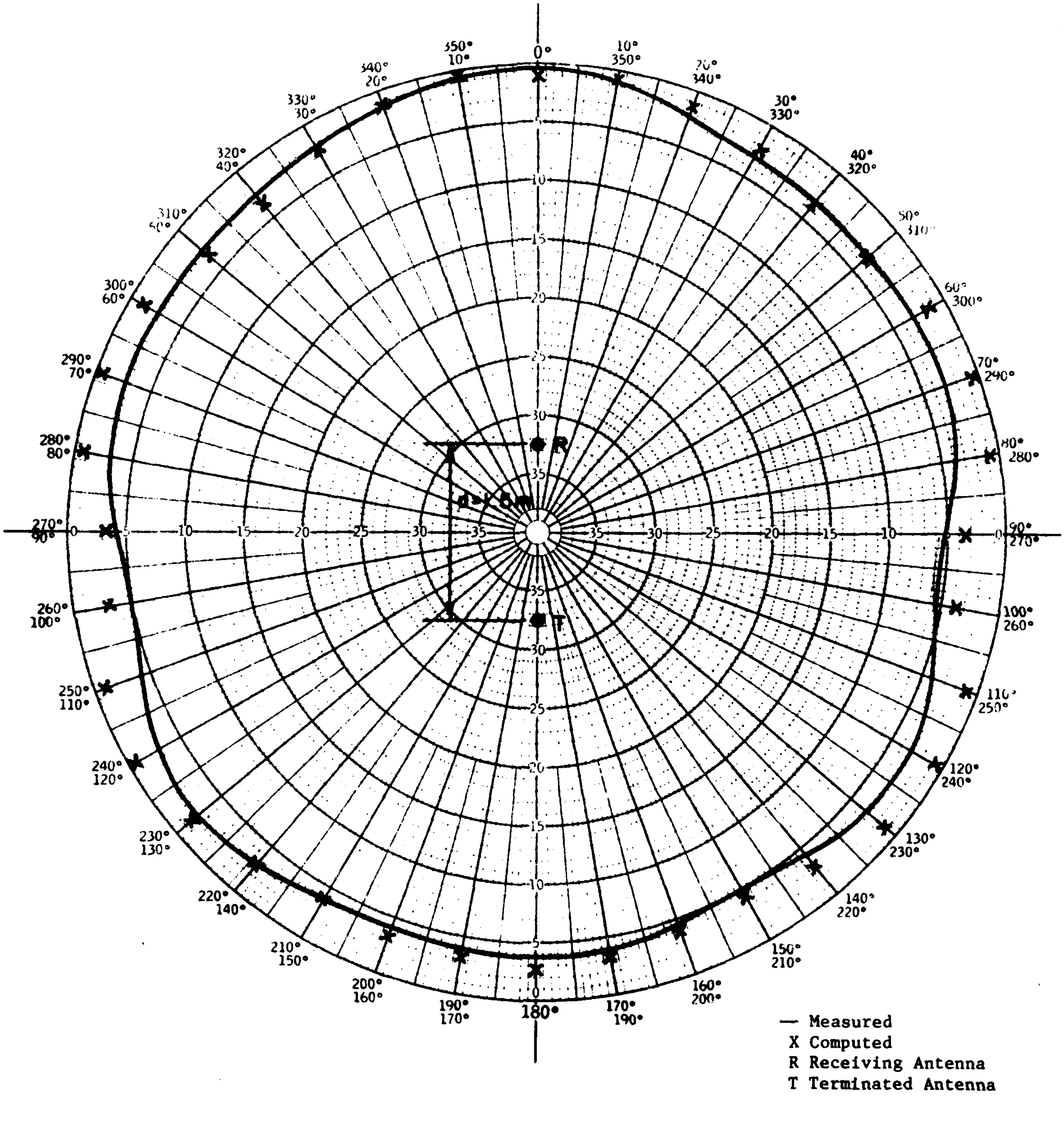
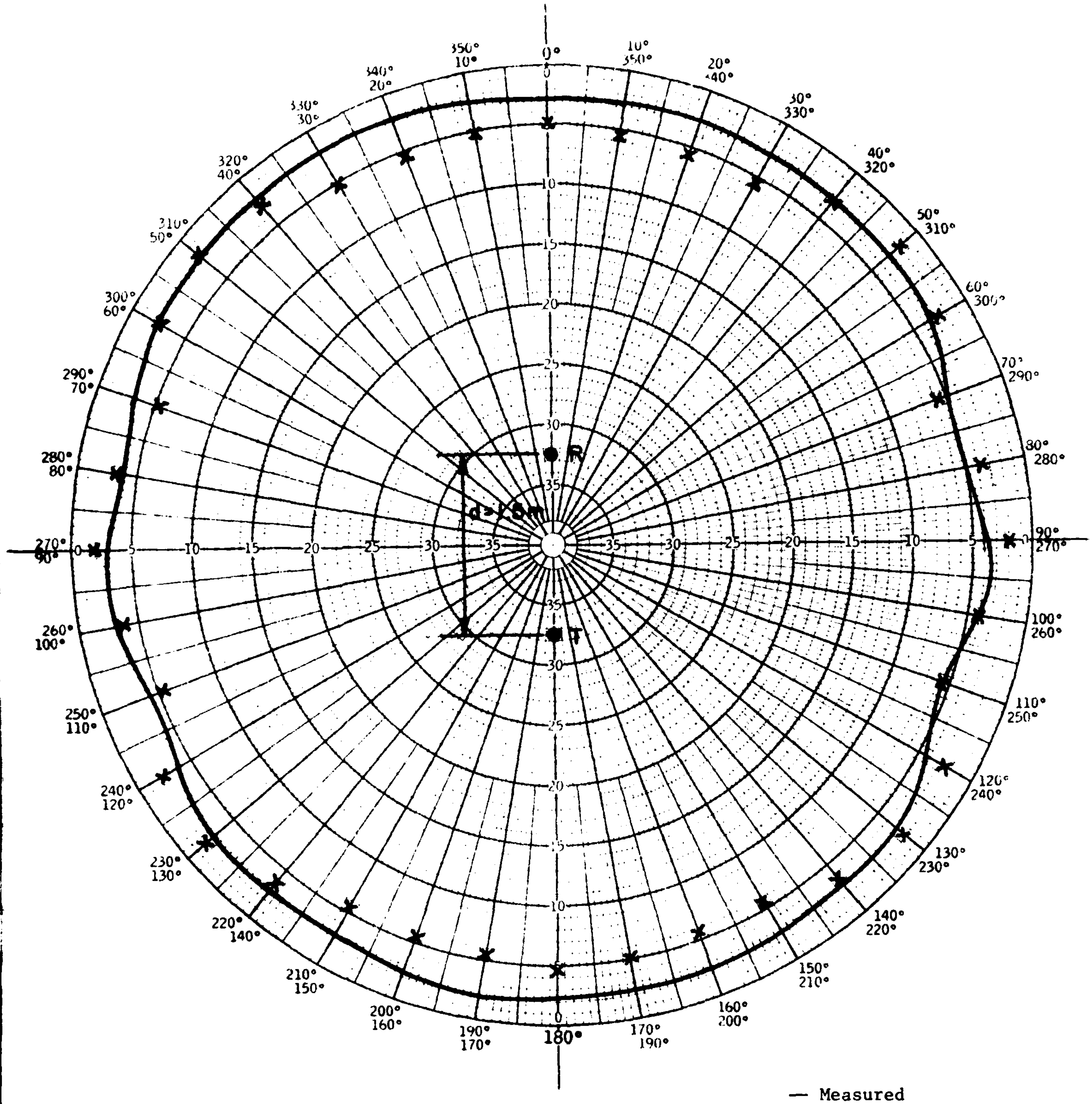


Figure 12. Two AS-1097/GR, f = 250 MHz, d = 1.5 m, D = 9.75 m



— Measured
X Computed
R Receiving Antenna
T Terminated Antenna

Figure 13. Two AS-1097/GR, f = 325 MHz, d = 1.5 m, D = 9.75 m

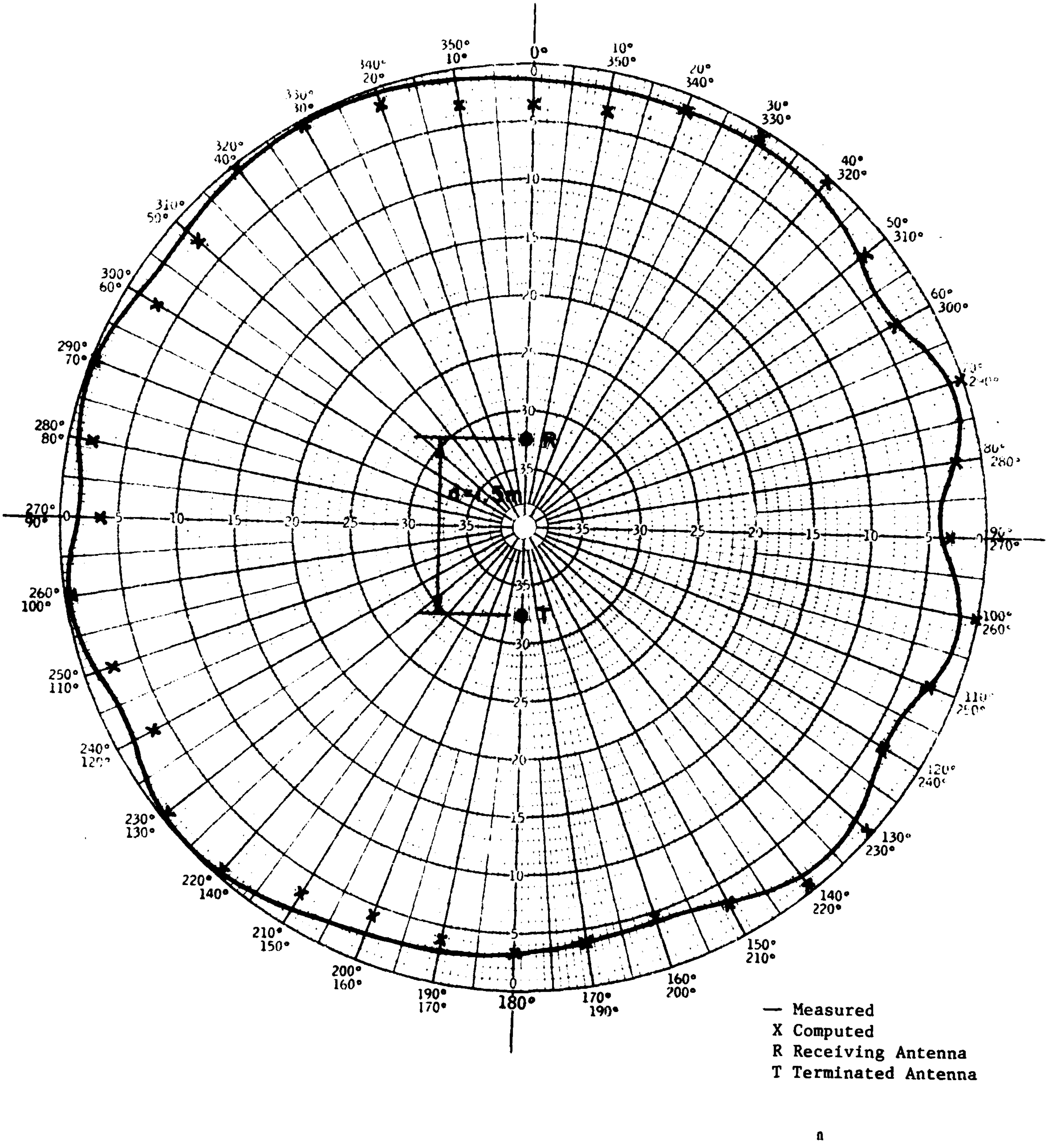
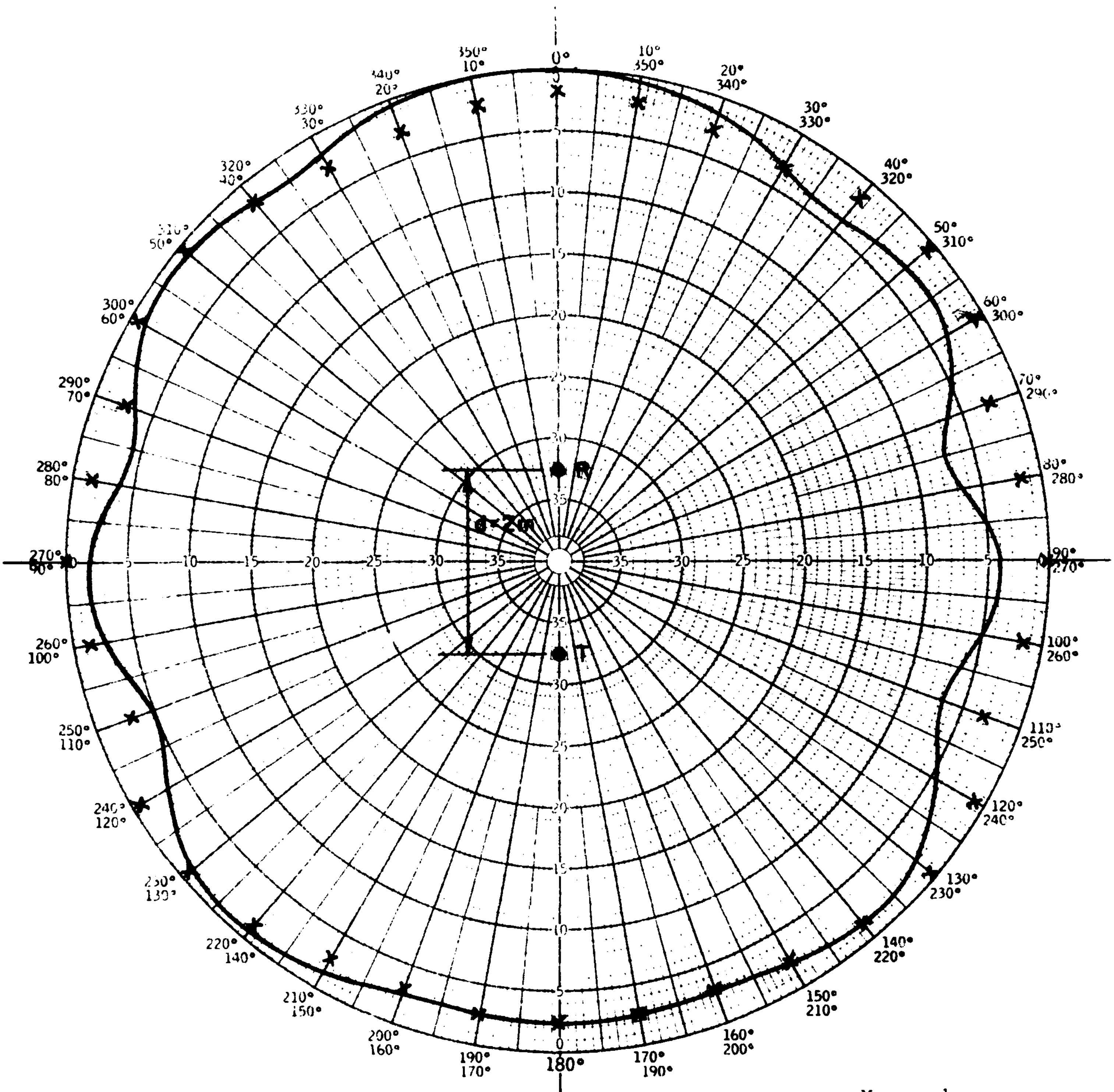


Figure 14. Two AS-1097/GR, f = 400 MHz, d = 1.5 m, D = 9.75 m



— Measured
X Computed
R Receiving Antenna
T Terminated Antenna

Figure 15. Two AS-1097/GR, f = 250 MHz, d = 2 m, D = 9.75 m

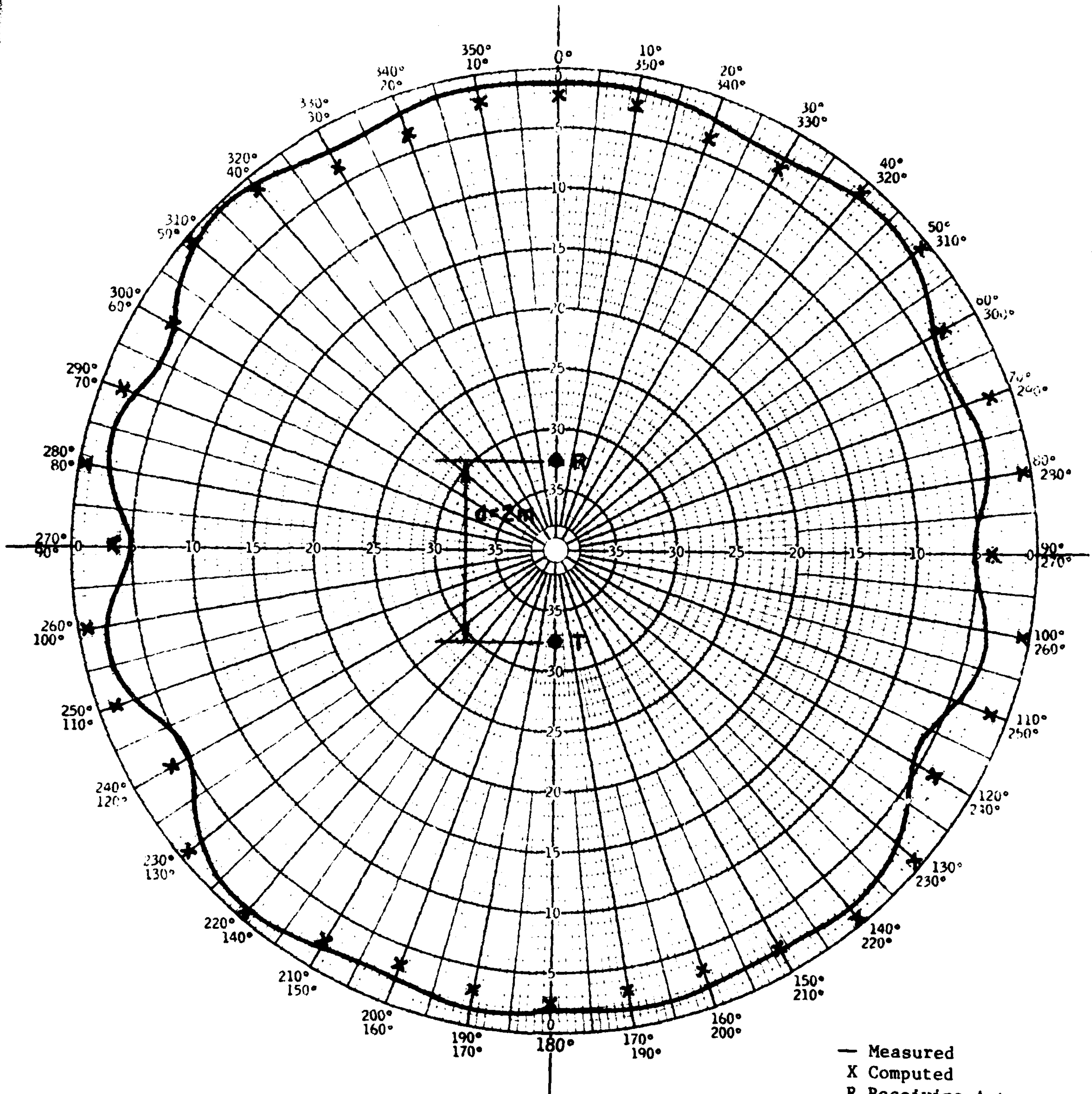


Figure 16. Two AS-1097/GR, f = 325 MHz, d = 2 m, D = 9.75 m

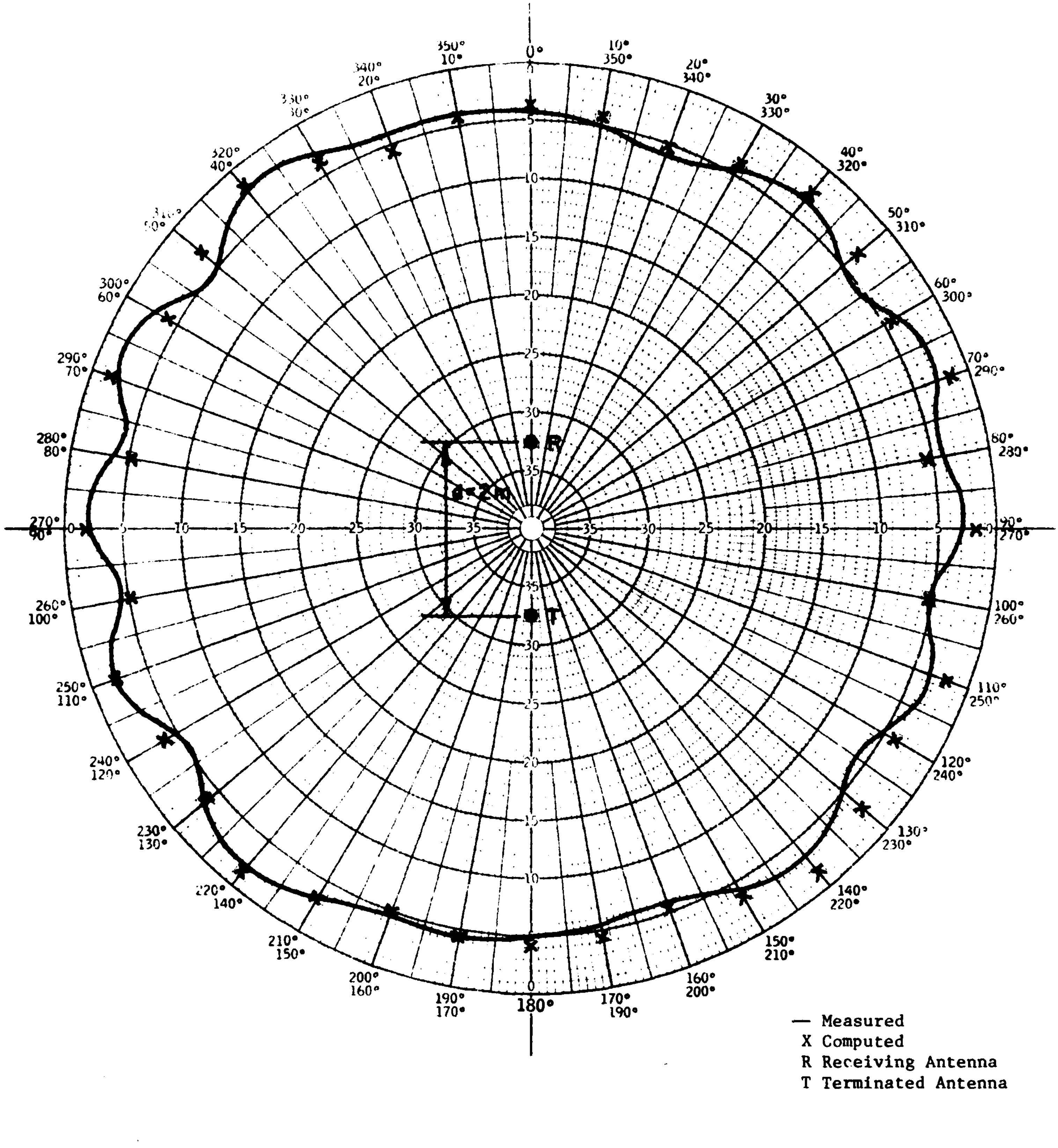


Figure 17. Two AS-1097/GR, f = 400 MHz, d = 2 m, D = 9.75 m

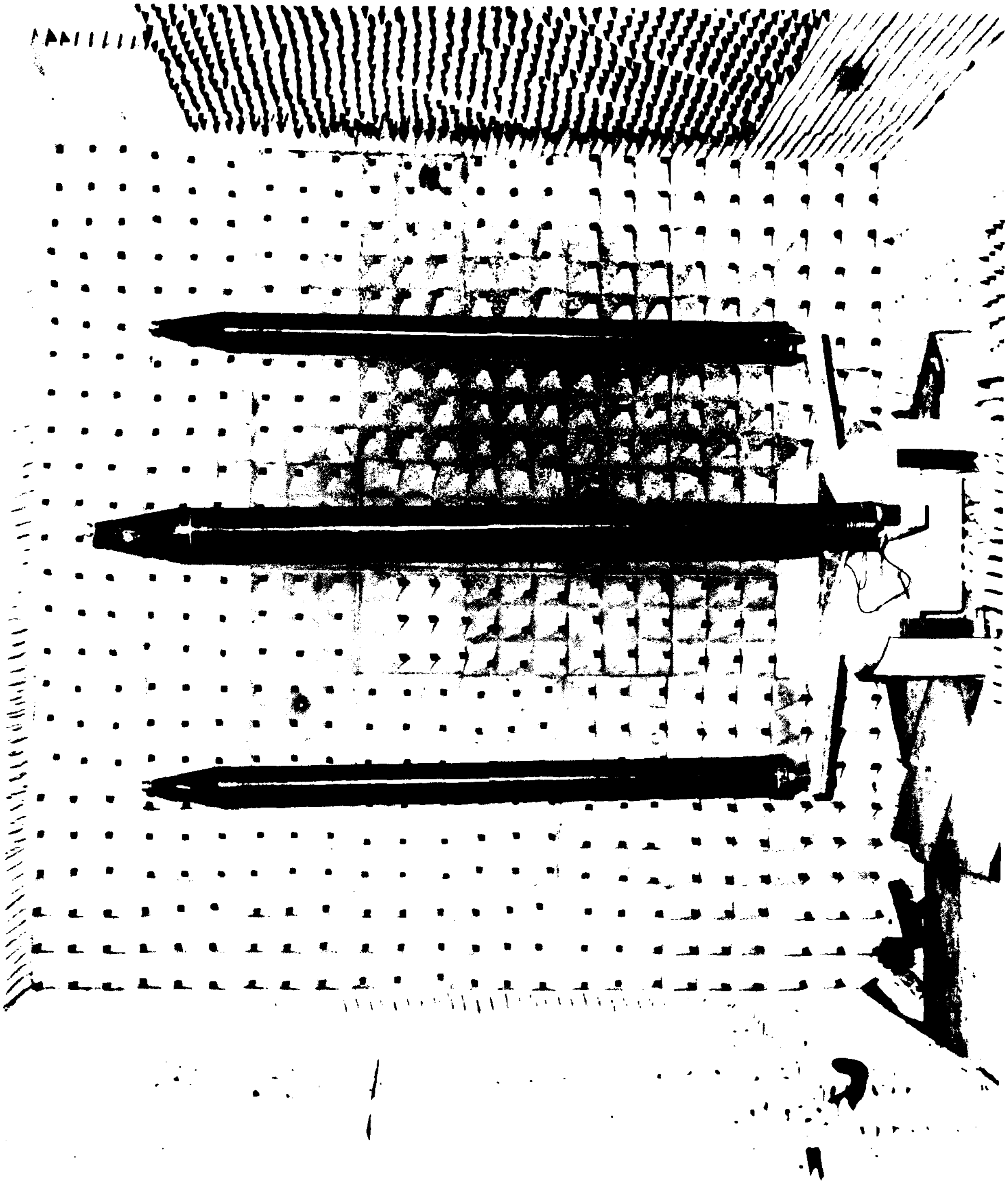


Figure 18. Anechoic Chamber Setup for Three AS-1097/GR Measurements

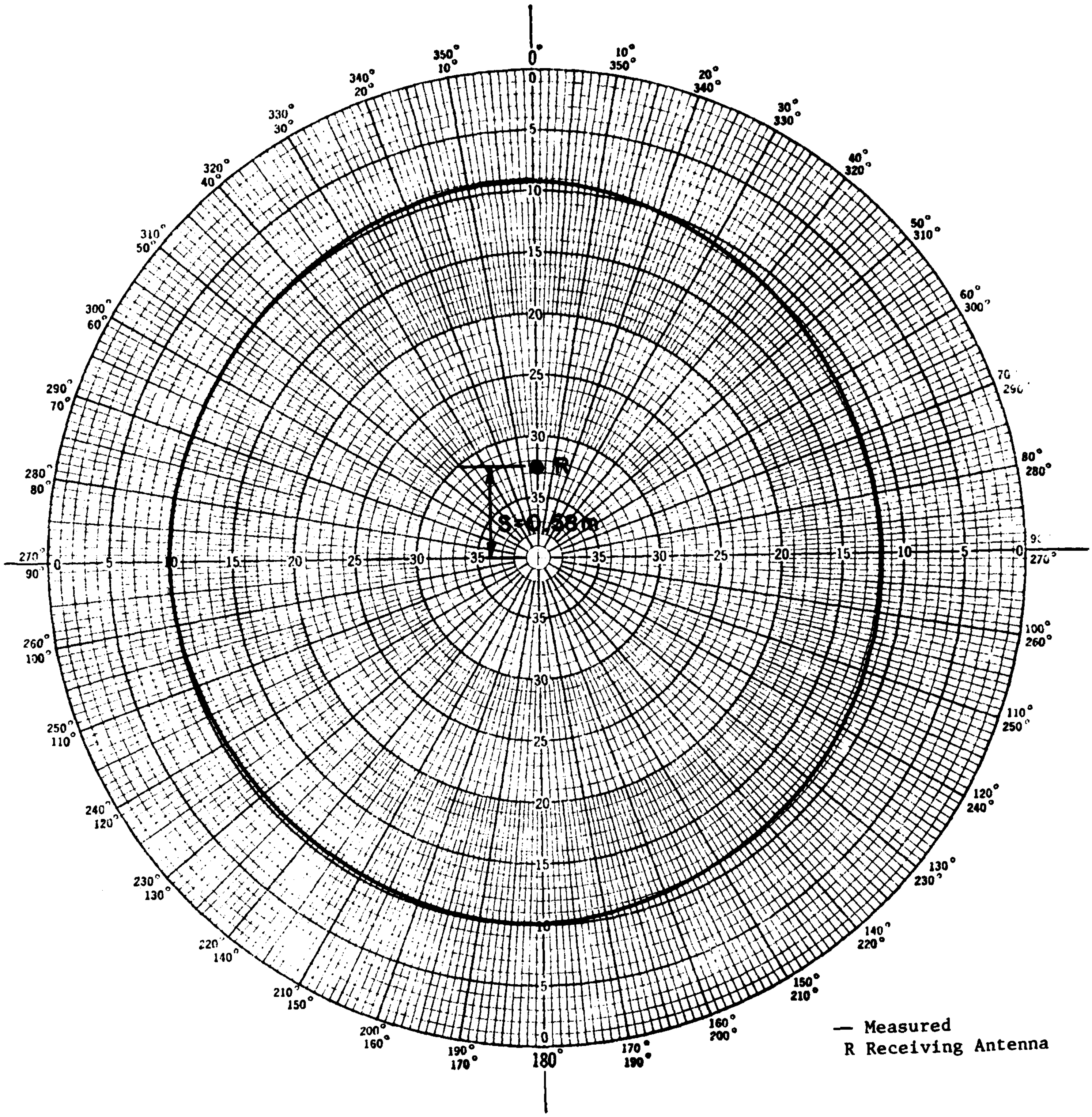


Figure 19. One AS-1097/GR, f = 250 MHz, d = 1 m for Three Antenna Setup, D = 9.75 m

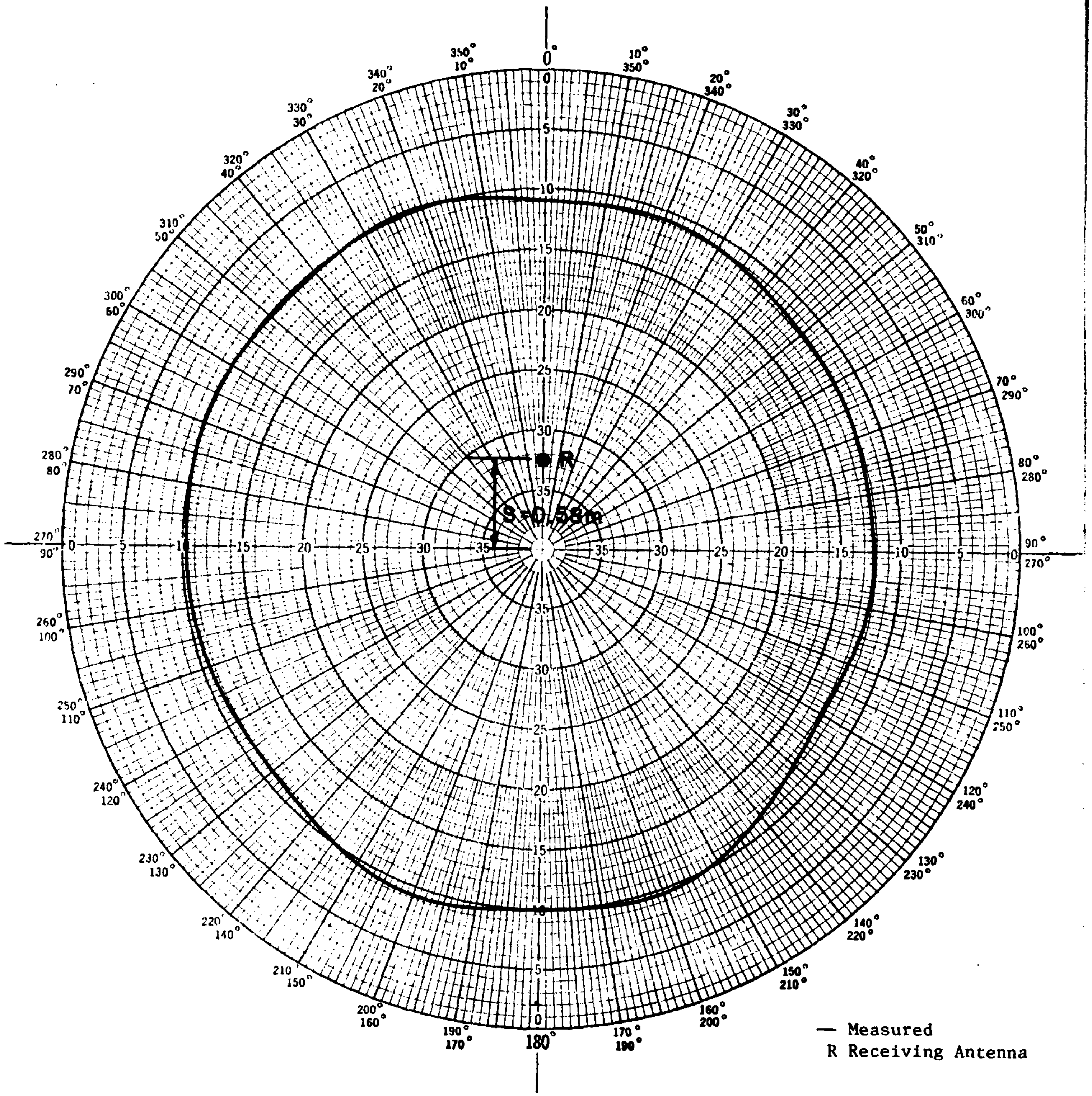


Figure 20. One AS-1097/GR, f = 325 MHz, d = 1 m for Three Antenna Setup, D = 9.75 m

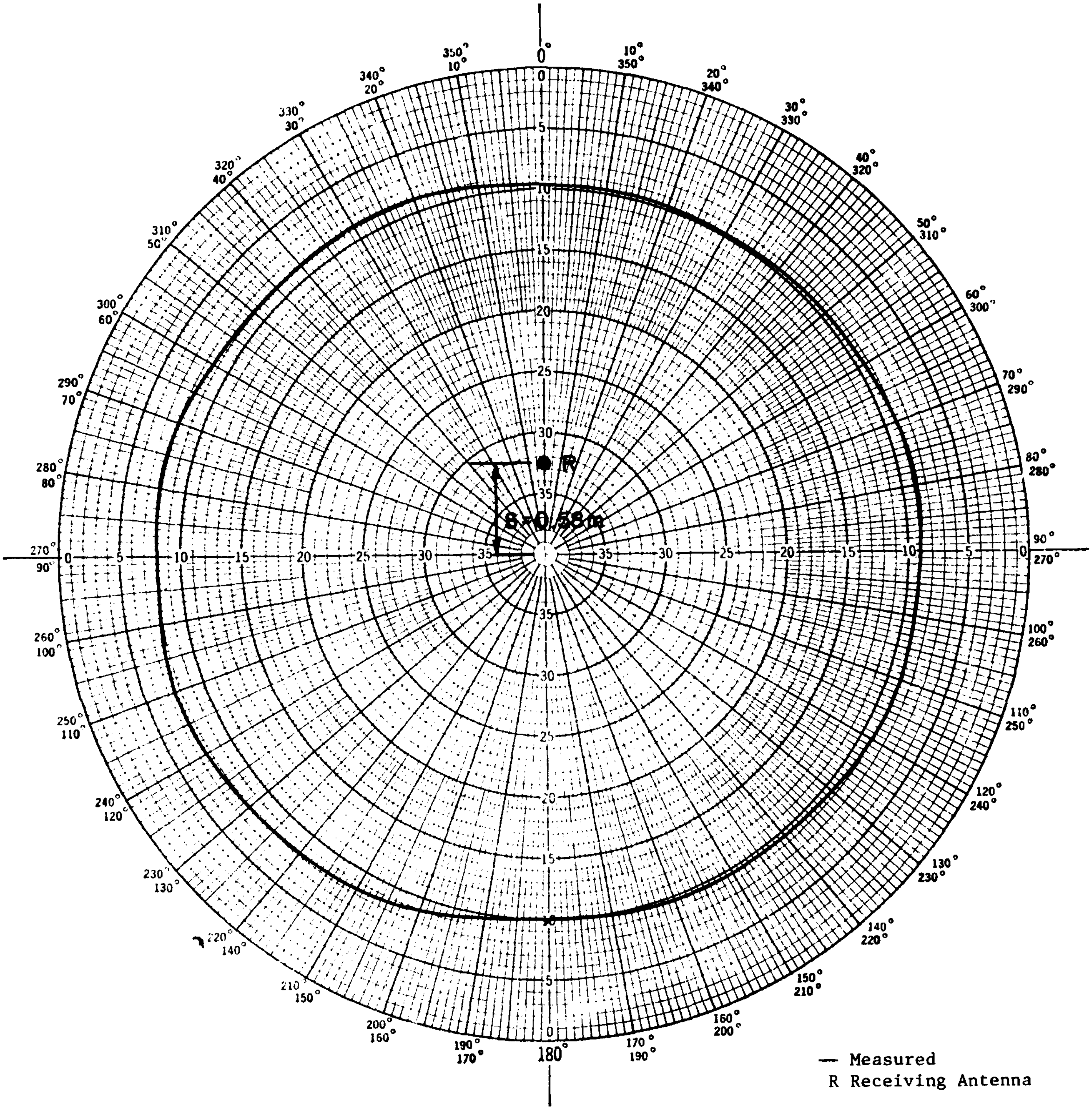
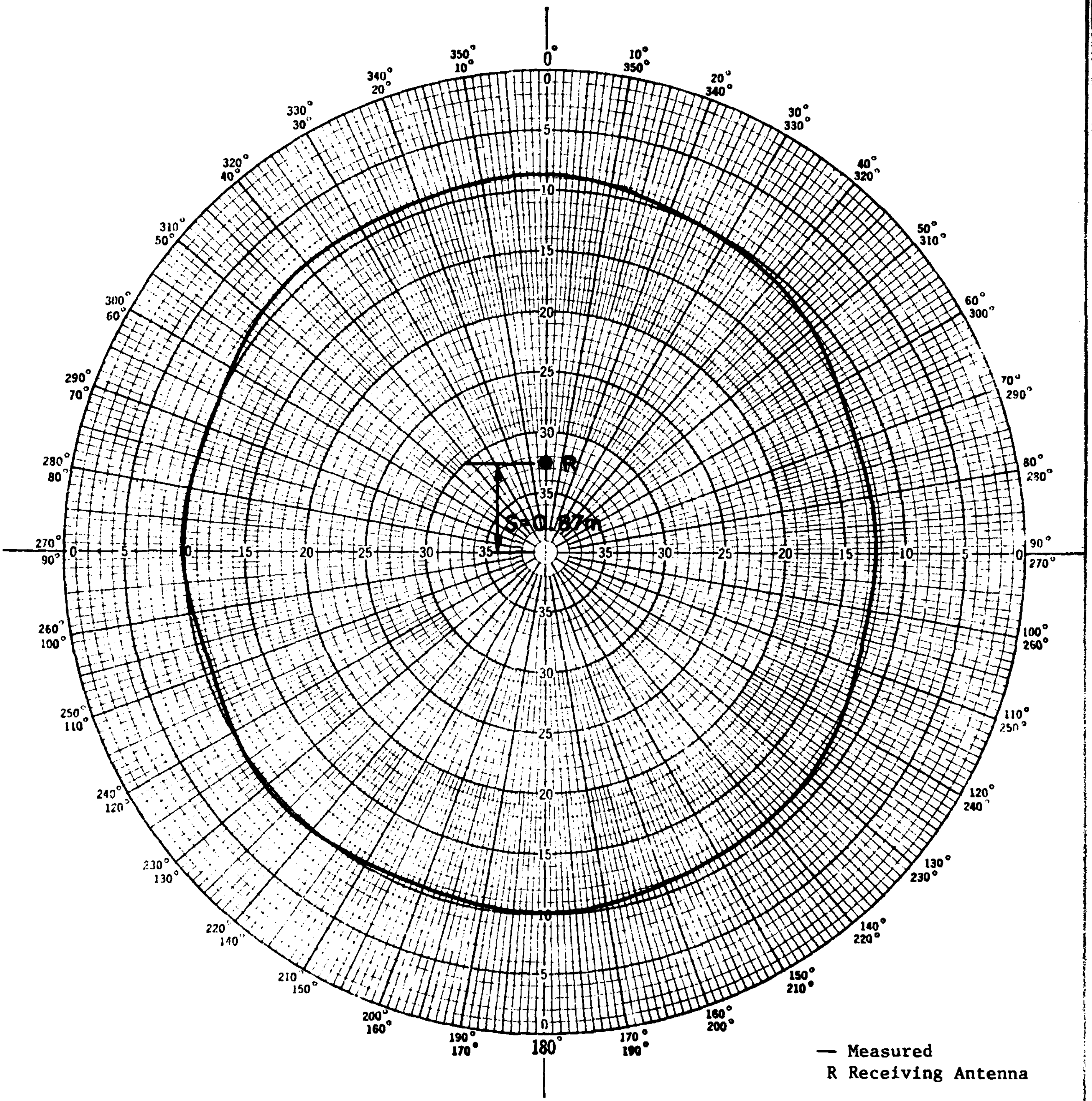


Figure 21. One AS-1097/GR, f = 400 MHz, d = 1 m for Three Antenna Setup, D = 9.75 m



— Measured
R Receiving Antenna

Figure 22. One AS-1097/GR, f = 250 MHz, d = 1.5 m for Three Antenna Setup, D = 9.75 m

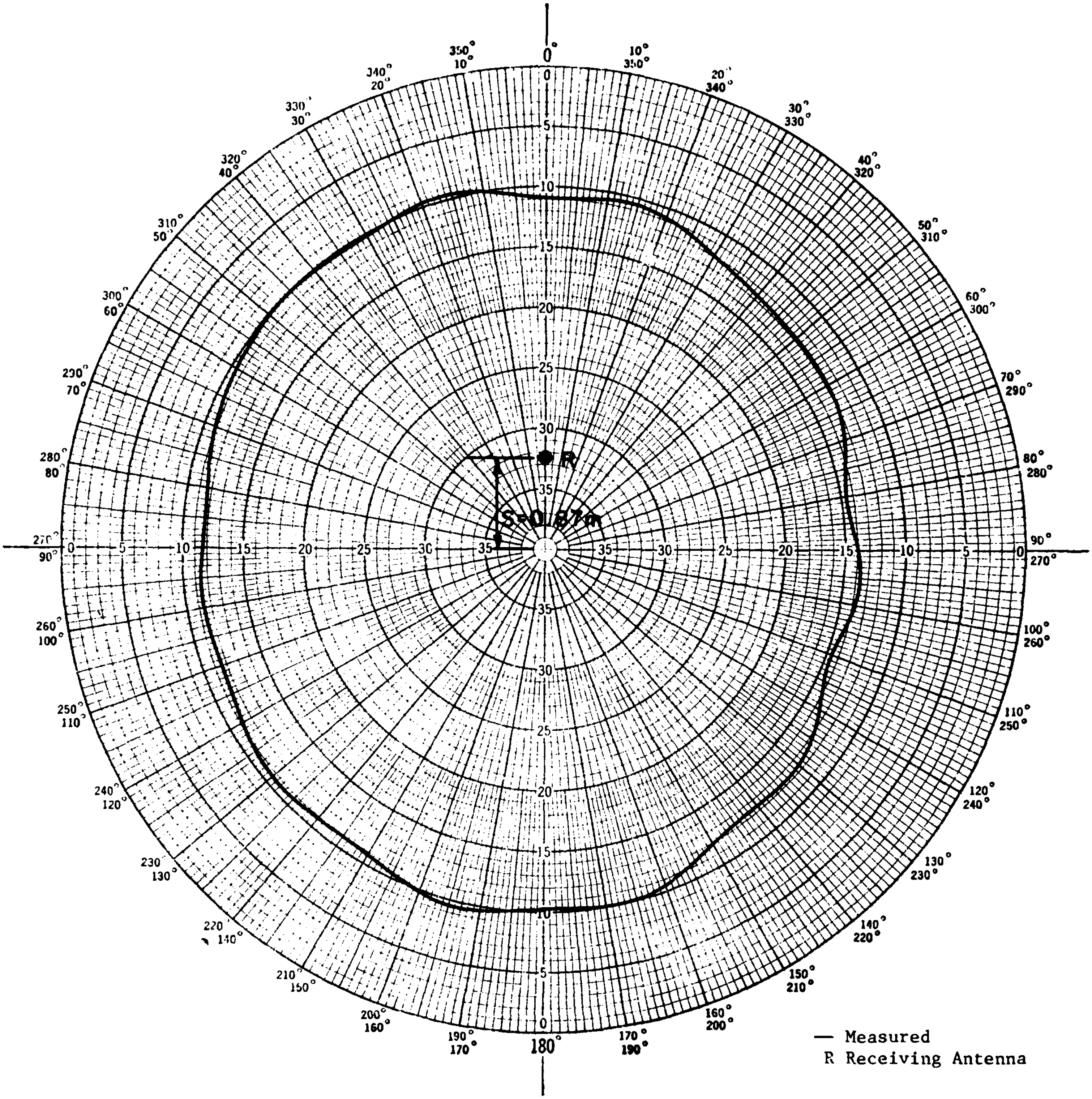


Figure 23. One AS-1097/GR, f = 325 MHz, d = 1.5 m for Three Antenna Setup, D = 9.75 m

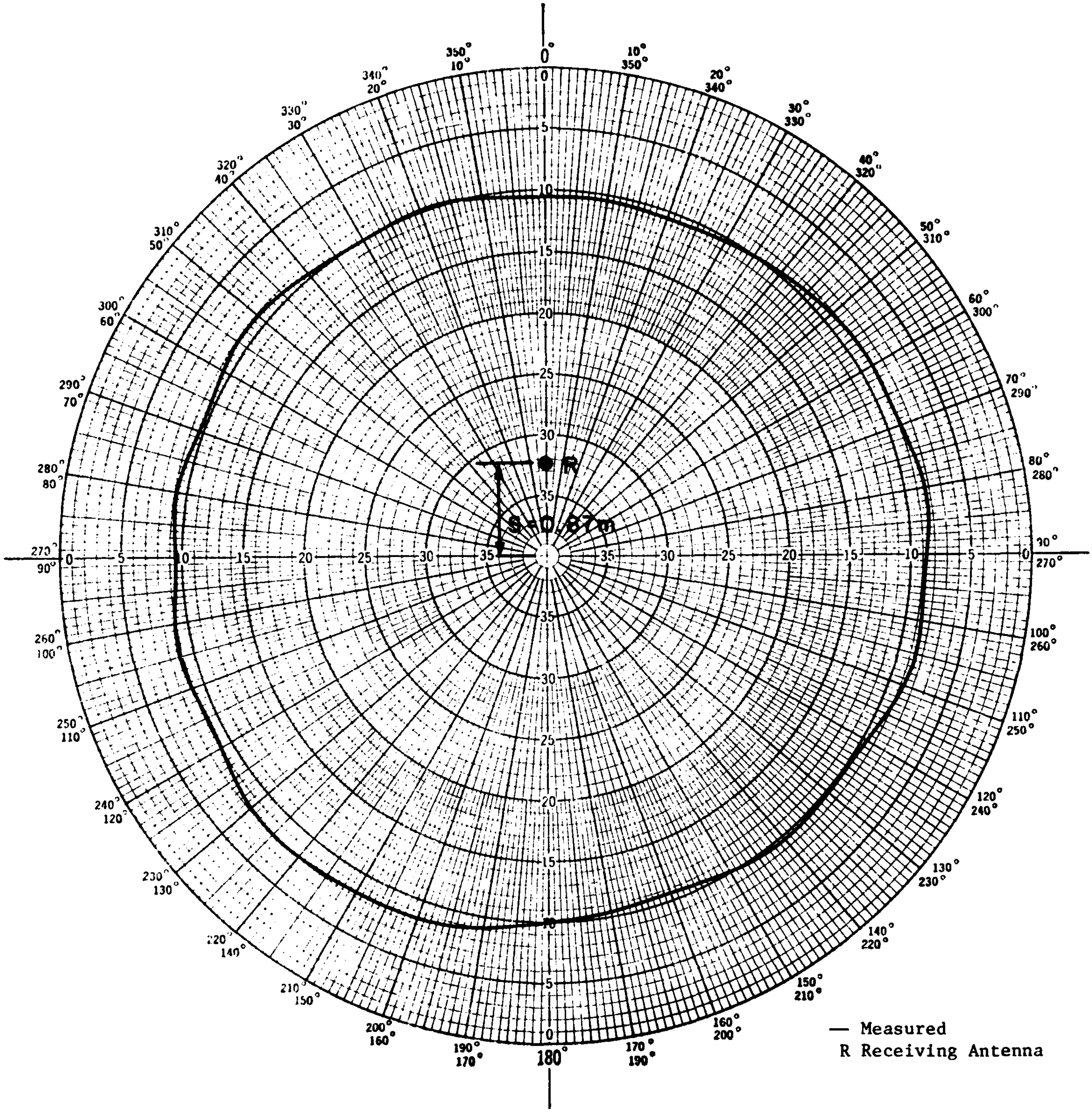


Figure 24. One AS-1097/GR, f = 400 MHz, d = 1.5 m for Three Antenna Setup, D = 9.75 m

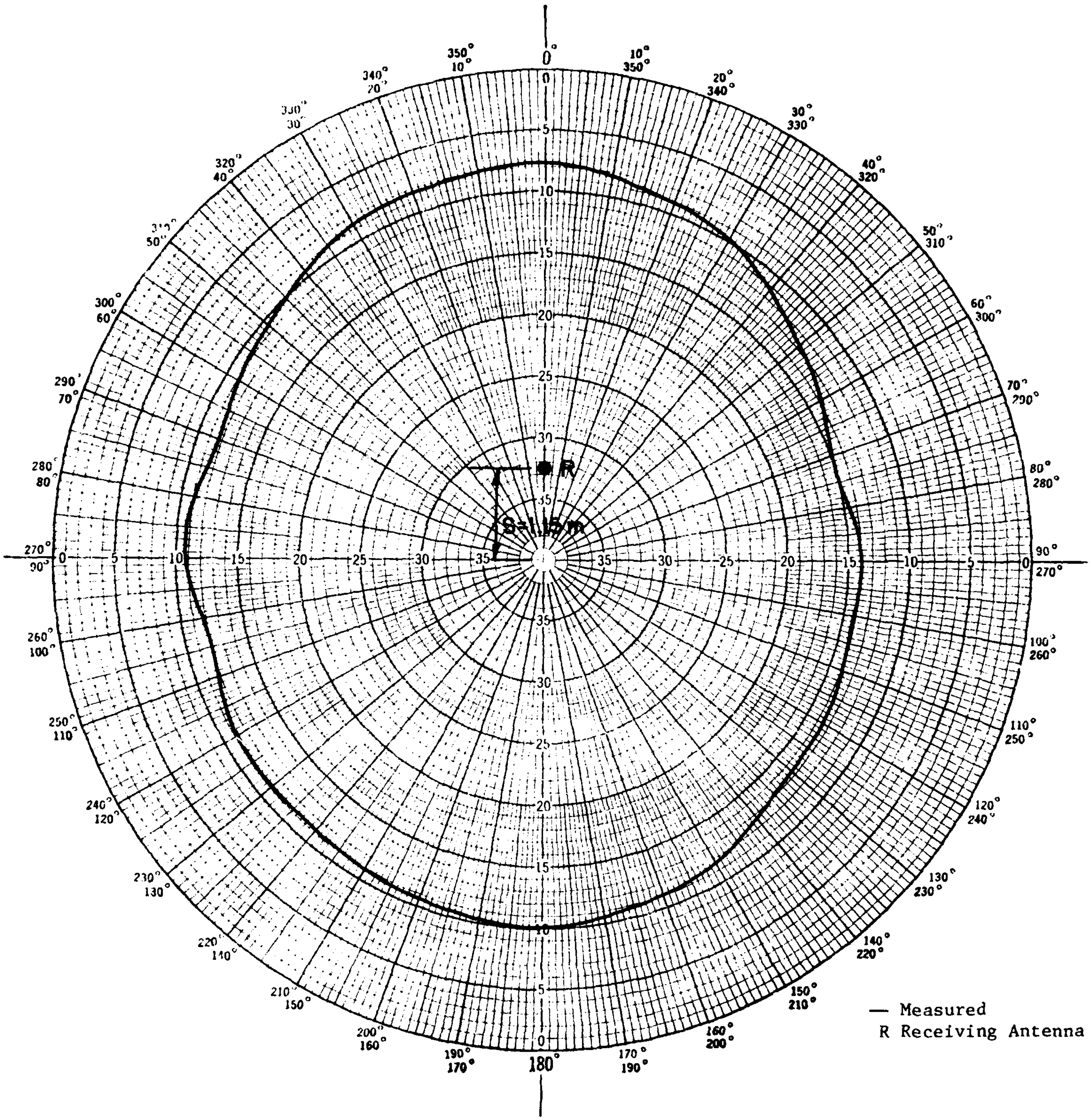


Figure 25. One AS-1097/GR, f = 250 MHz, d = 2 m for Three Antenna Setup, D = 9.75 m

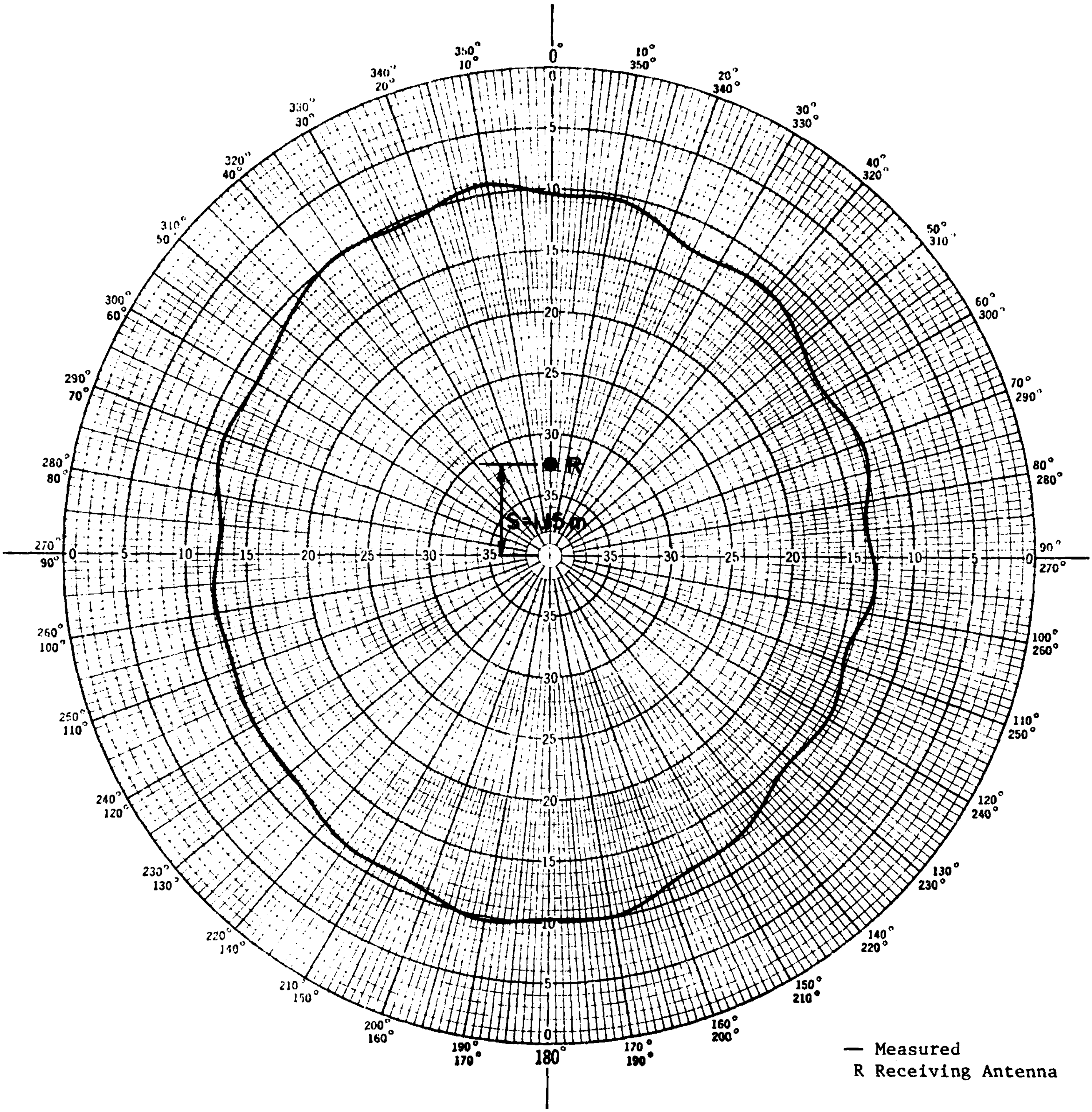


Figure 26. One AS-1097/GR, f = 325 MHz, d = 2 m for Three Antenna Setup, D = 9.75 m

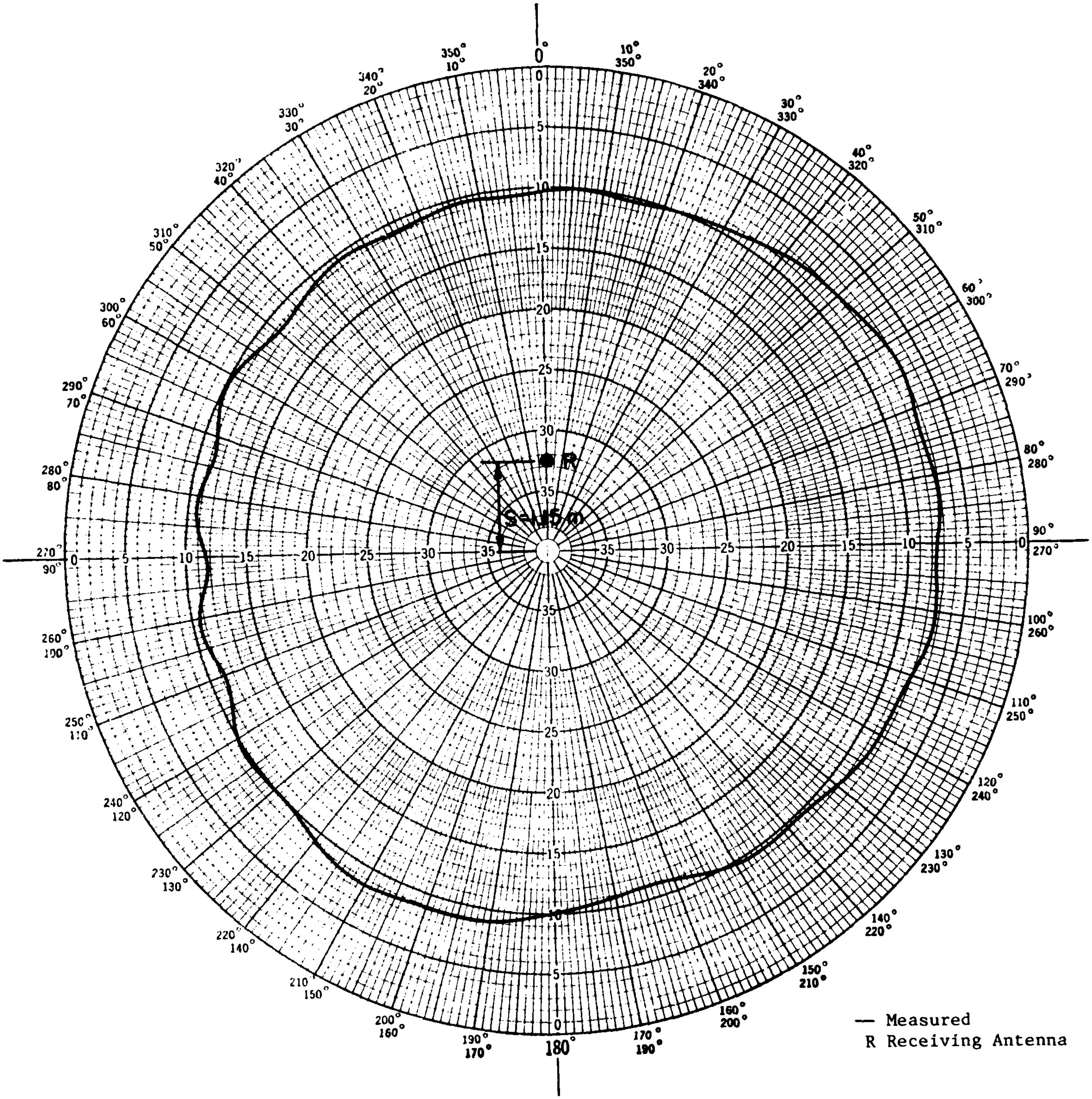


Figure 27. One AS-1097/GR, f = 400 MHz, d = 2 m for Three Antenna Setup, D = 9.75 m

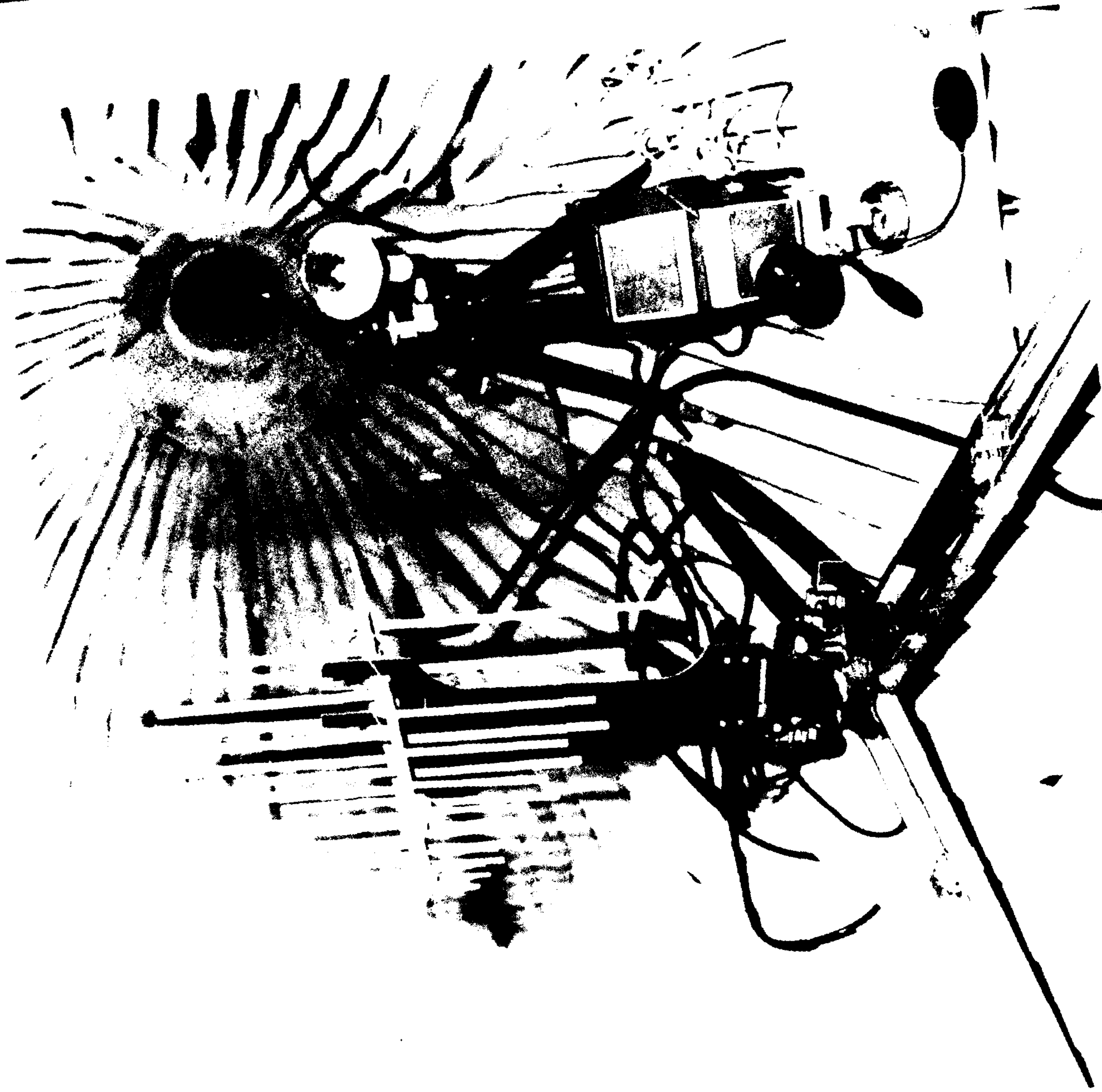


Figure 28. Illuminating Antenna for Three AS-1097/GR Measurements

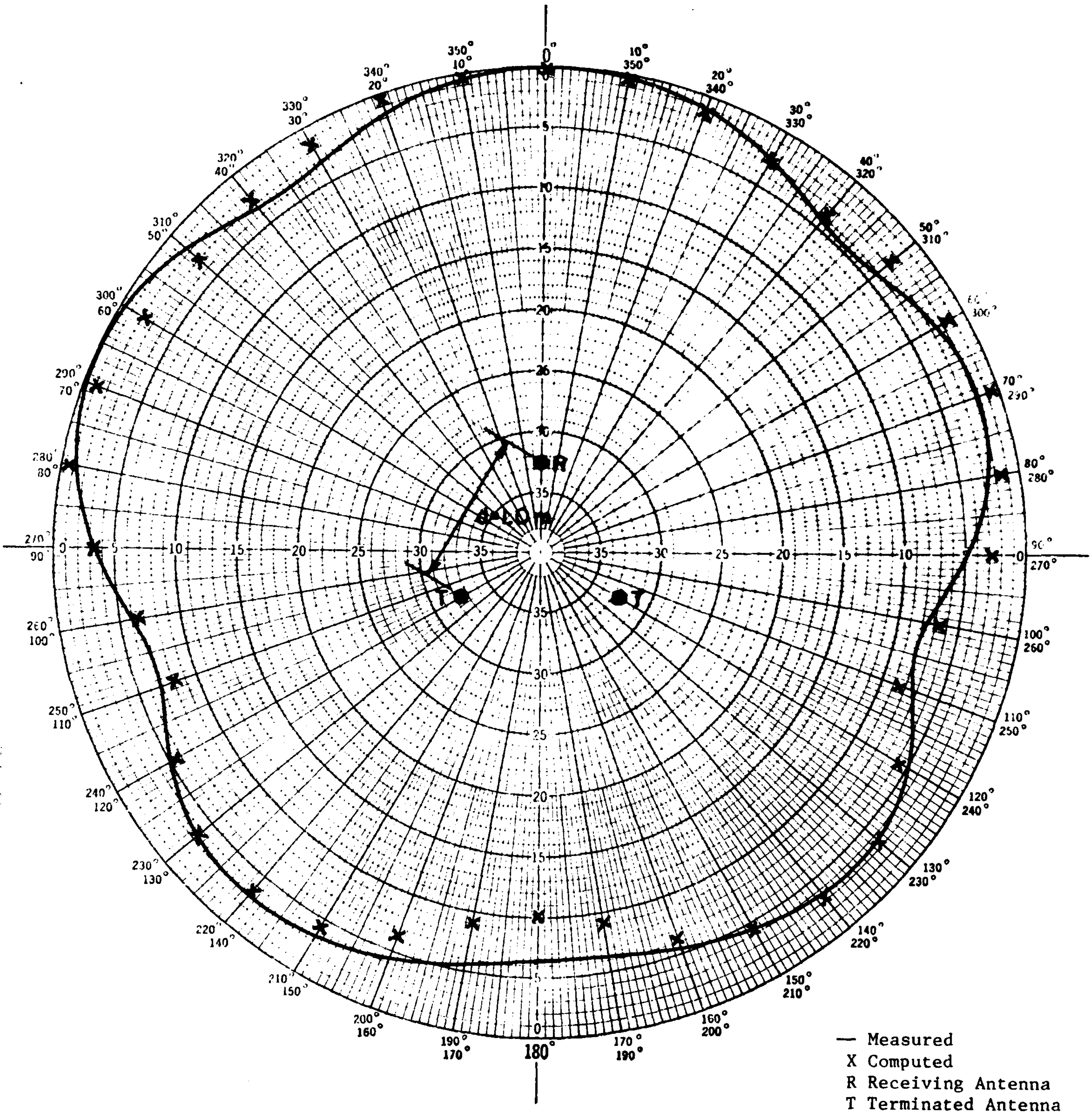
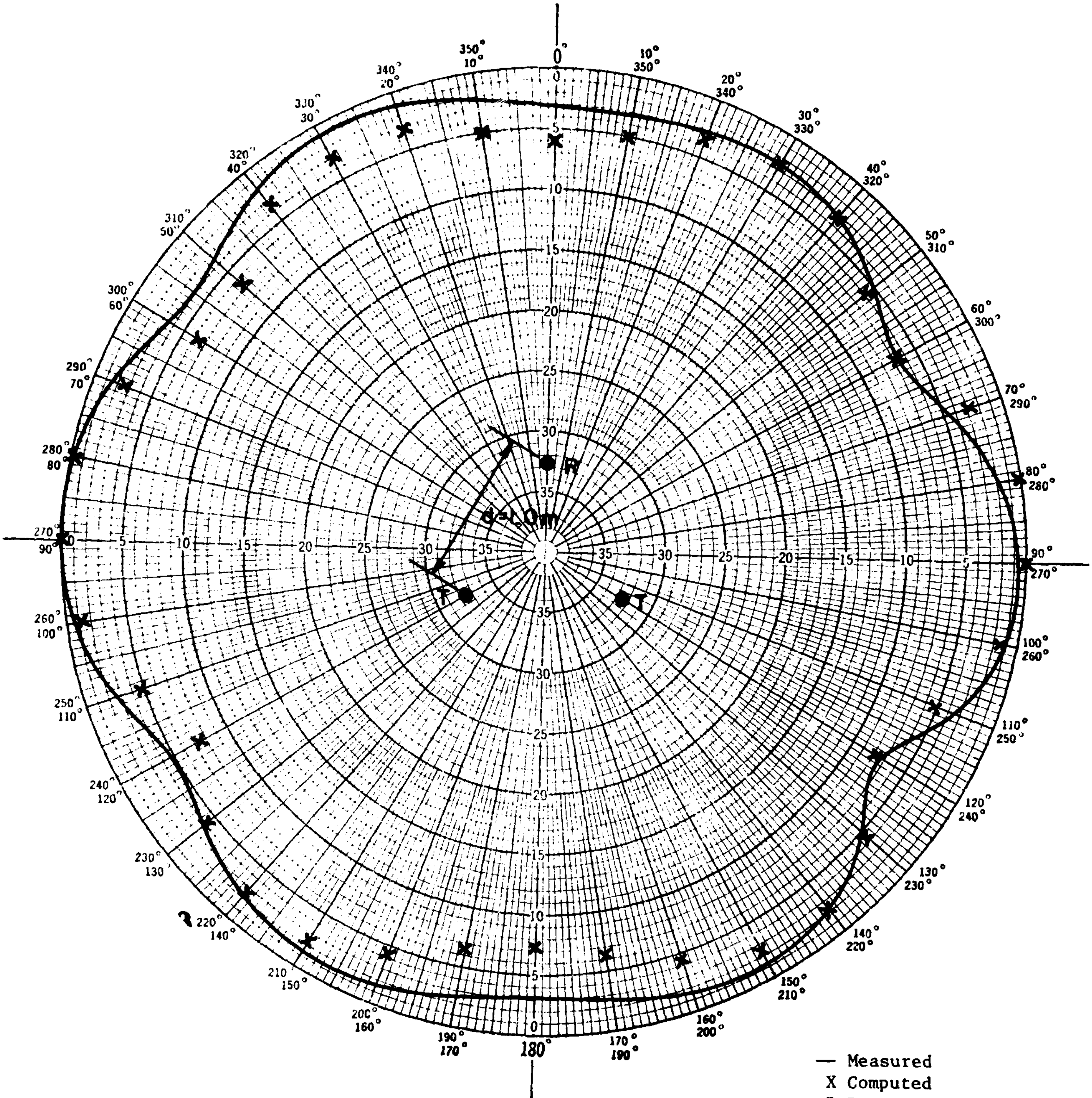


Figure 29. Three AS-1097/GR, f = 250 MHz, d = 1 m, D = 9.75 m



— Measured
X Computed
R Receiving Antenna
T Terminated Antenna

Figure 30. Three AS-1097/GR, f = 325 MHz, d = 1 m, D = 9.75 m

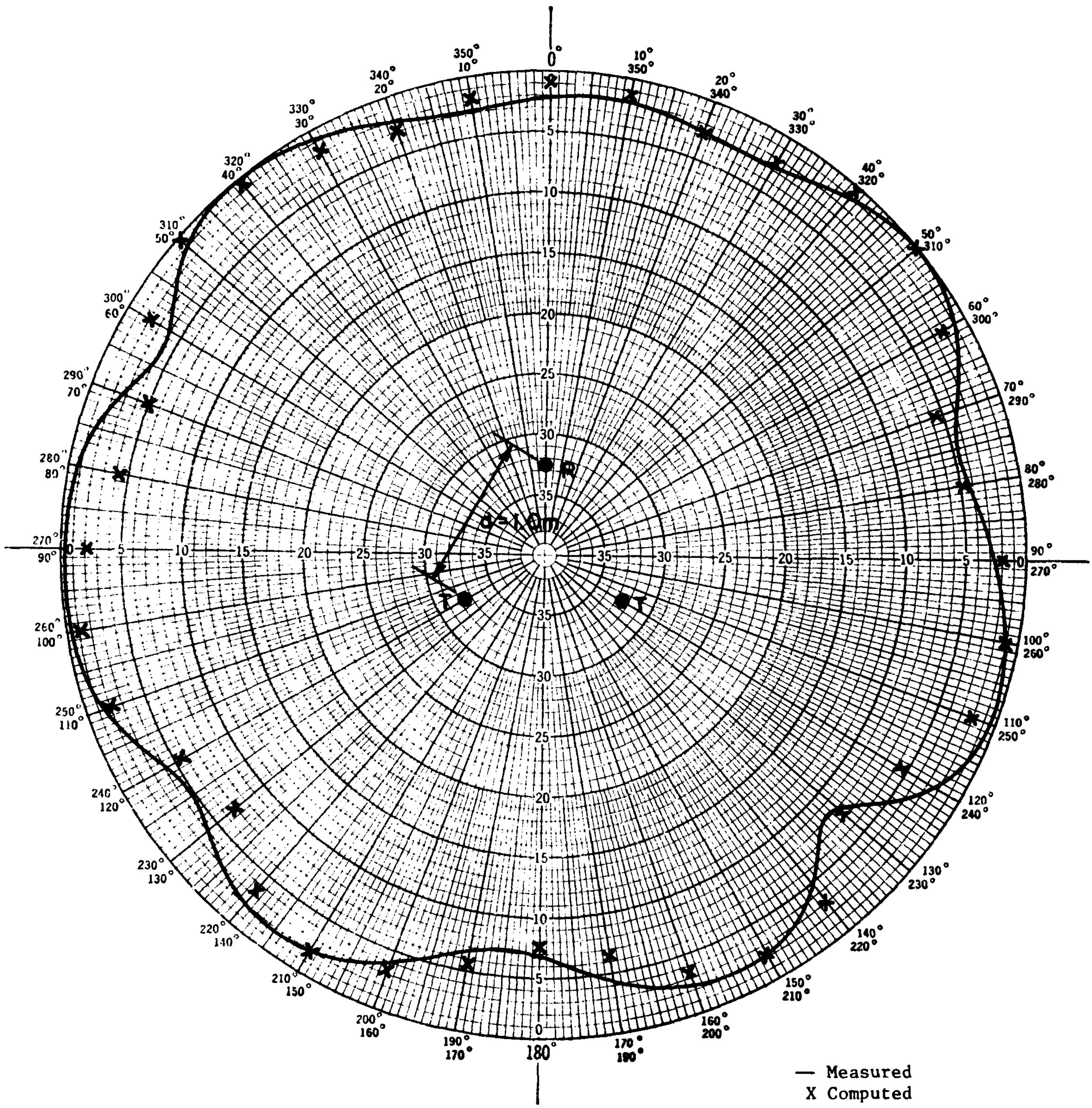


Figure 31. Three AS-1097/GR, f = 400 MHz, d = 1 m, D = 9.75 m

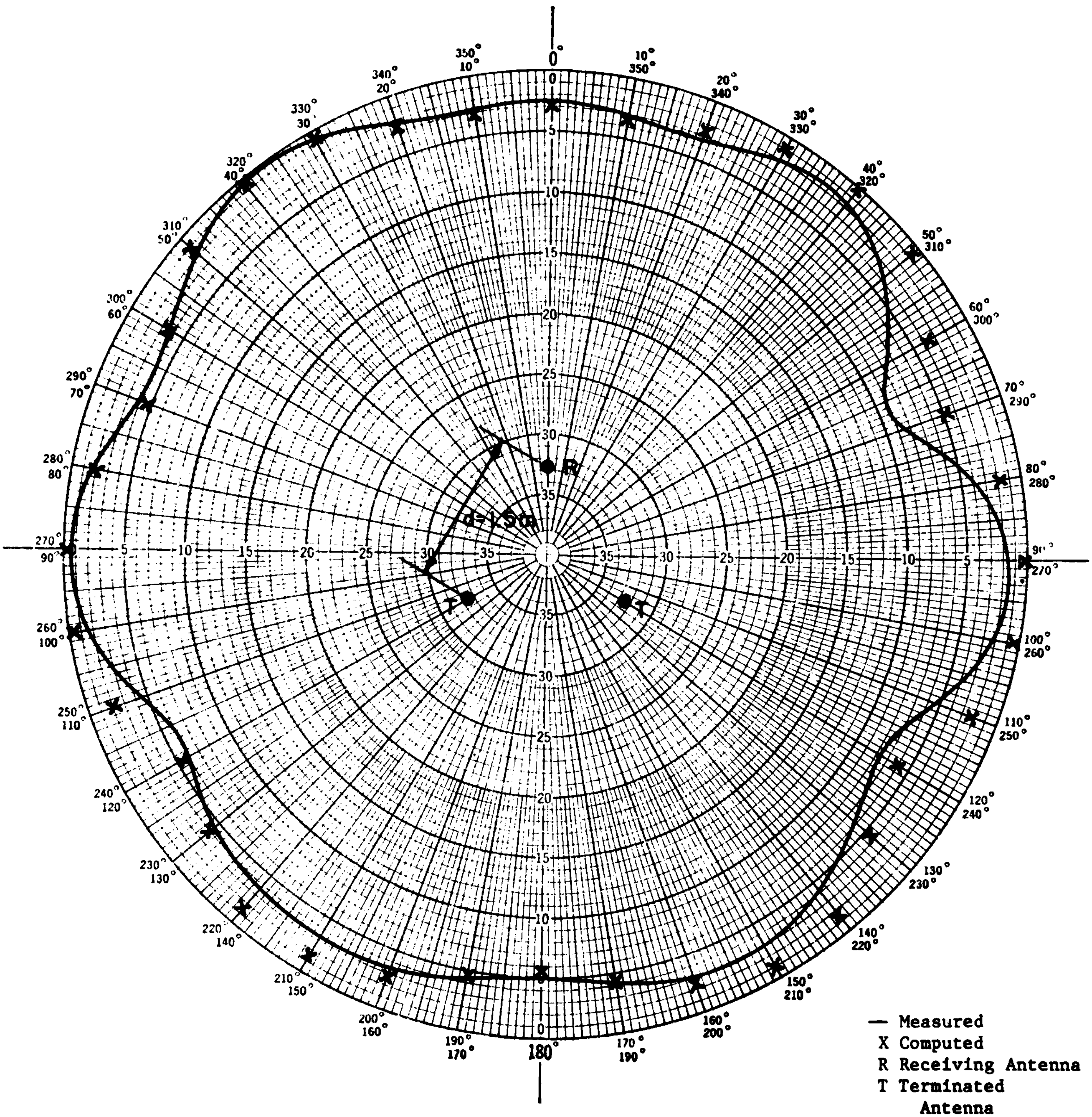


Figure 32. Three AS-1097/GR, f = 250 MHz, d = 1.5 m, D = 9.75 m

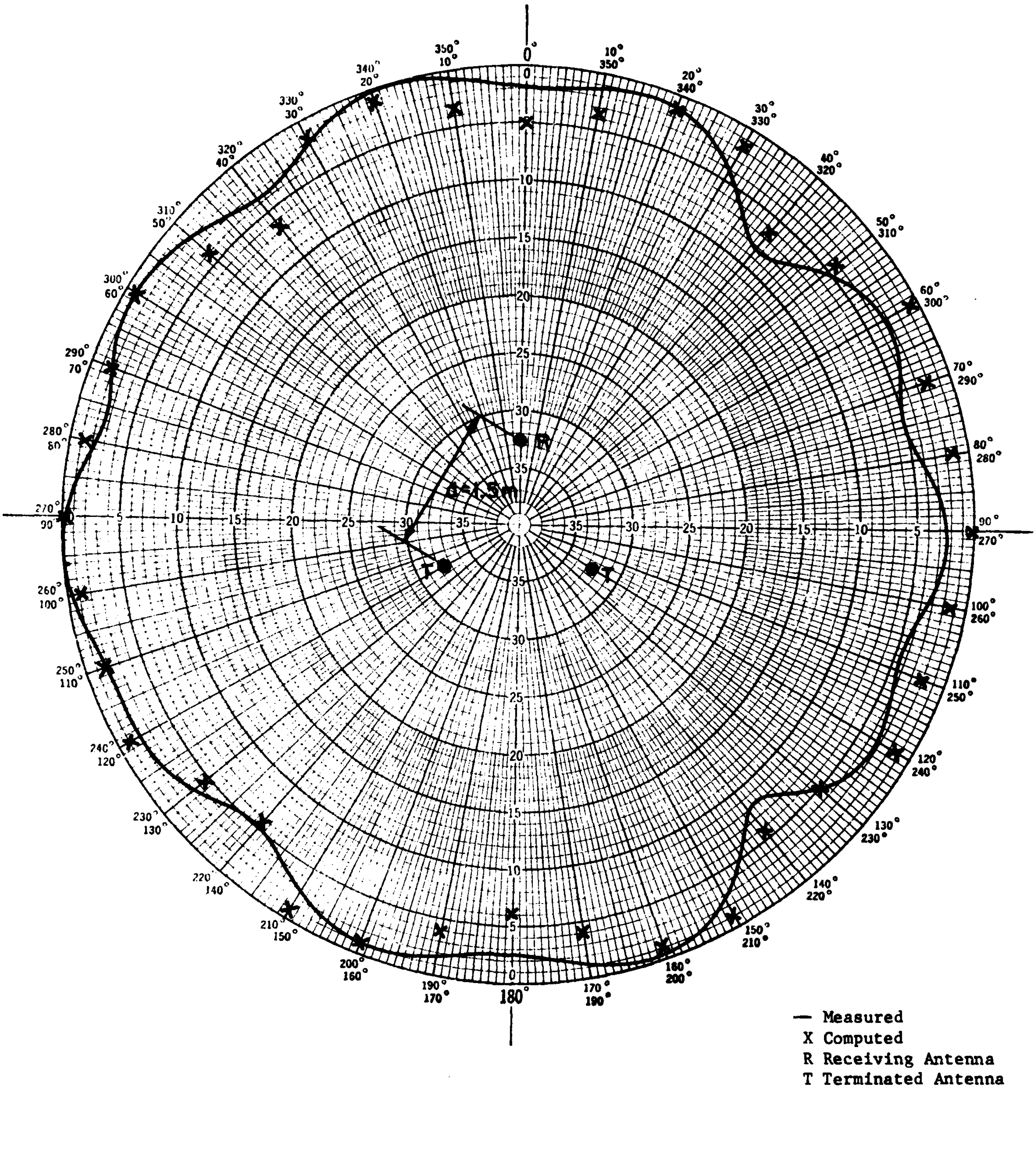


Figure 33. Three AS-1097/GR, f = 325 MHz, d = 1.5 m, D = 9.75 m

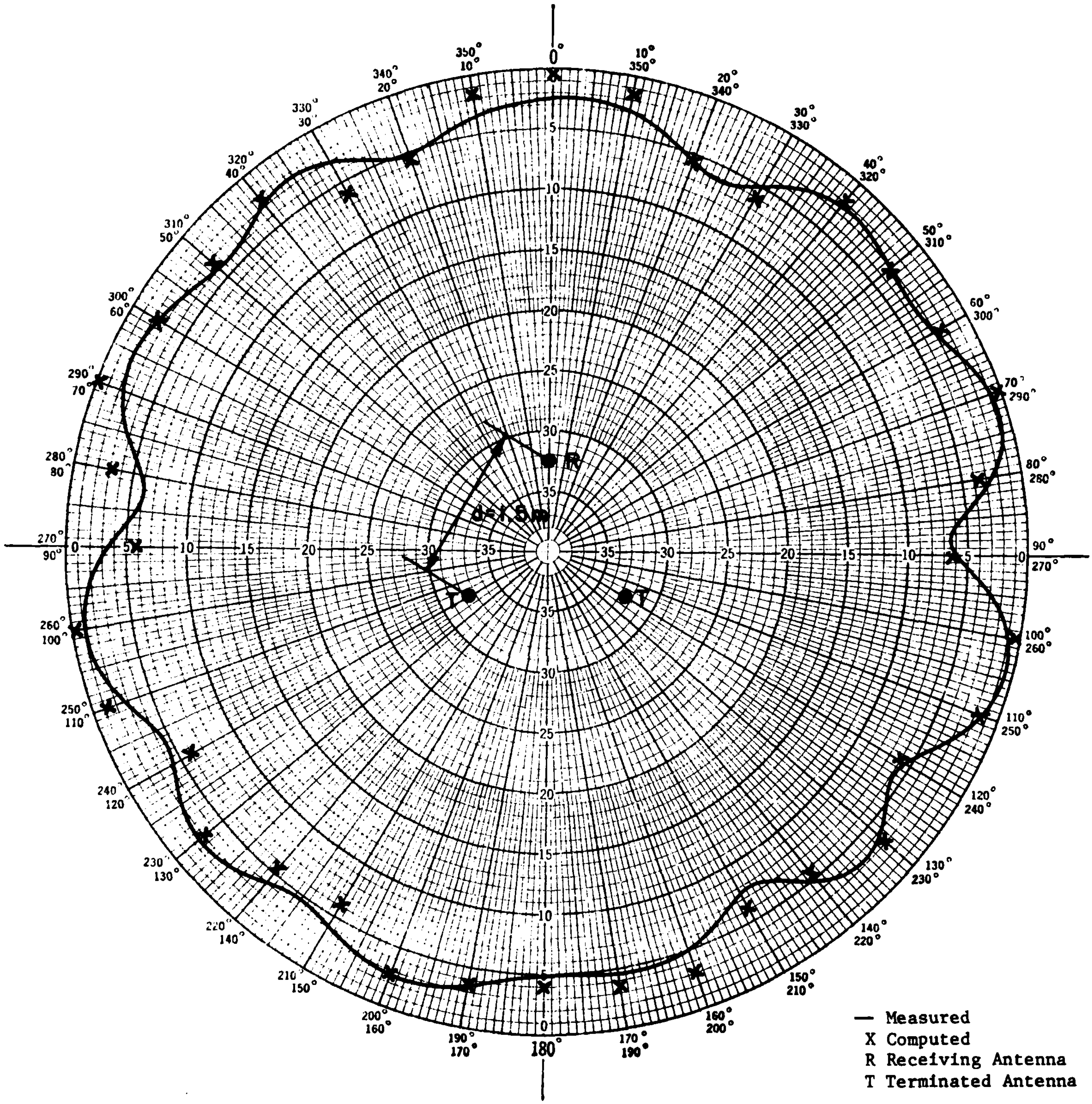


Figure 34. Three AS-1097/GR, f = 400 MHz, d = 1.5 m, D = 9.75 m

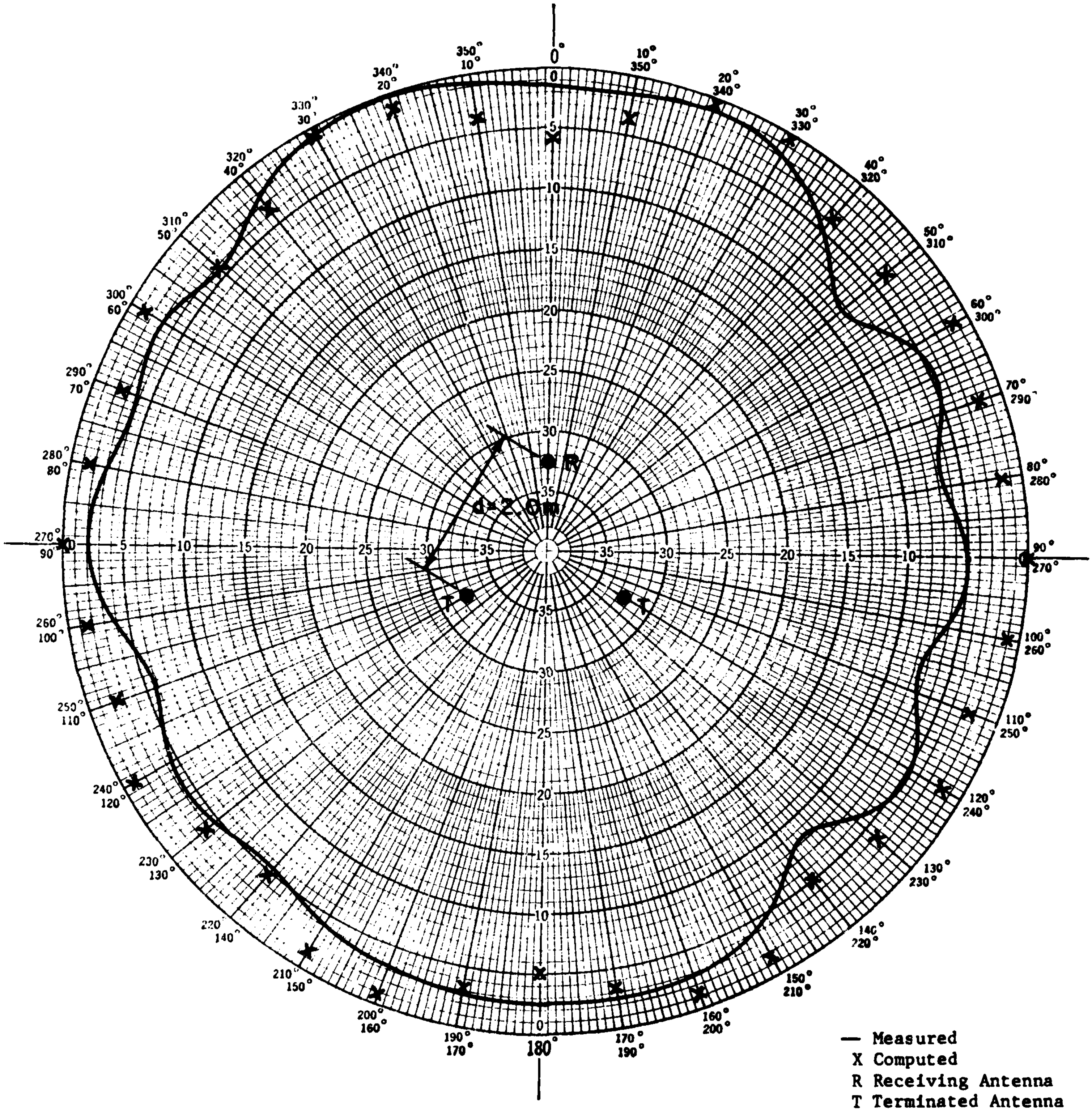


Figure 35. Three AS-1097/GR, f = 250 MHz, d = 2 m, D = 9.75 m

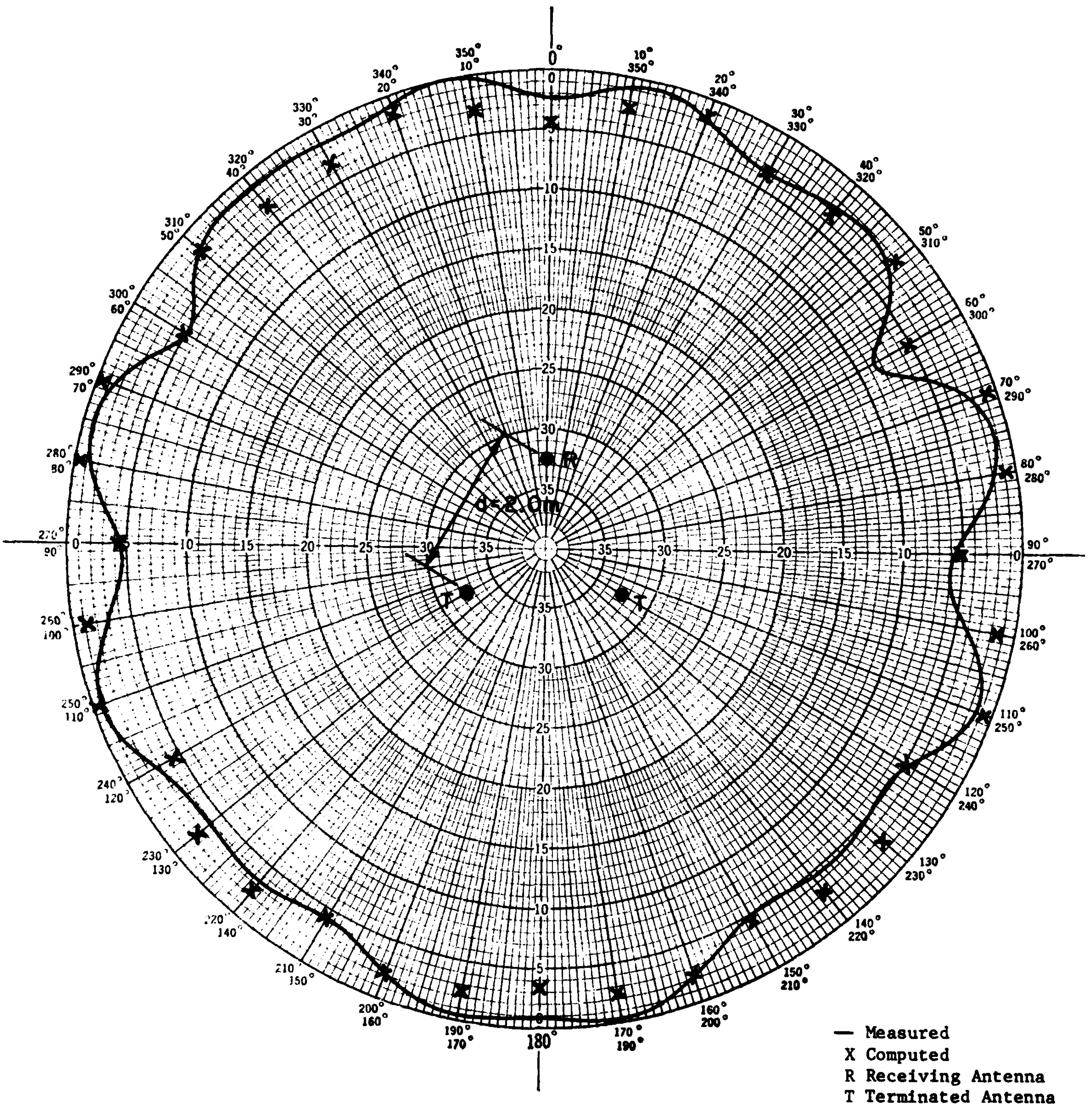


Figure 36. Three AS-1097/GR, f = 325 MHz, d = 2 m, D = 9.75 m

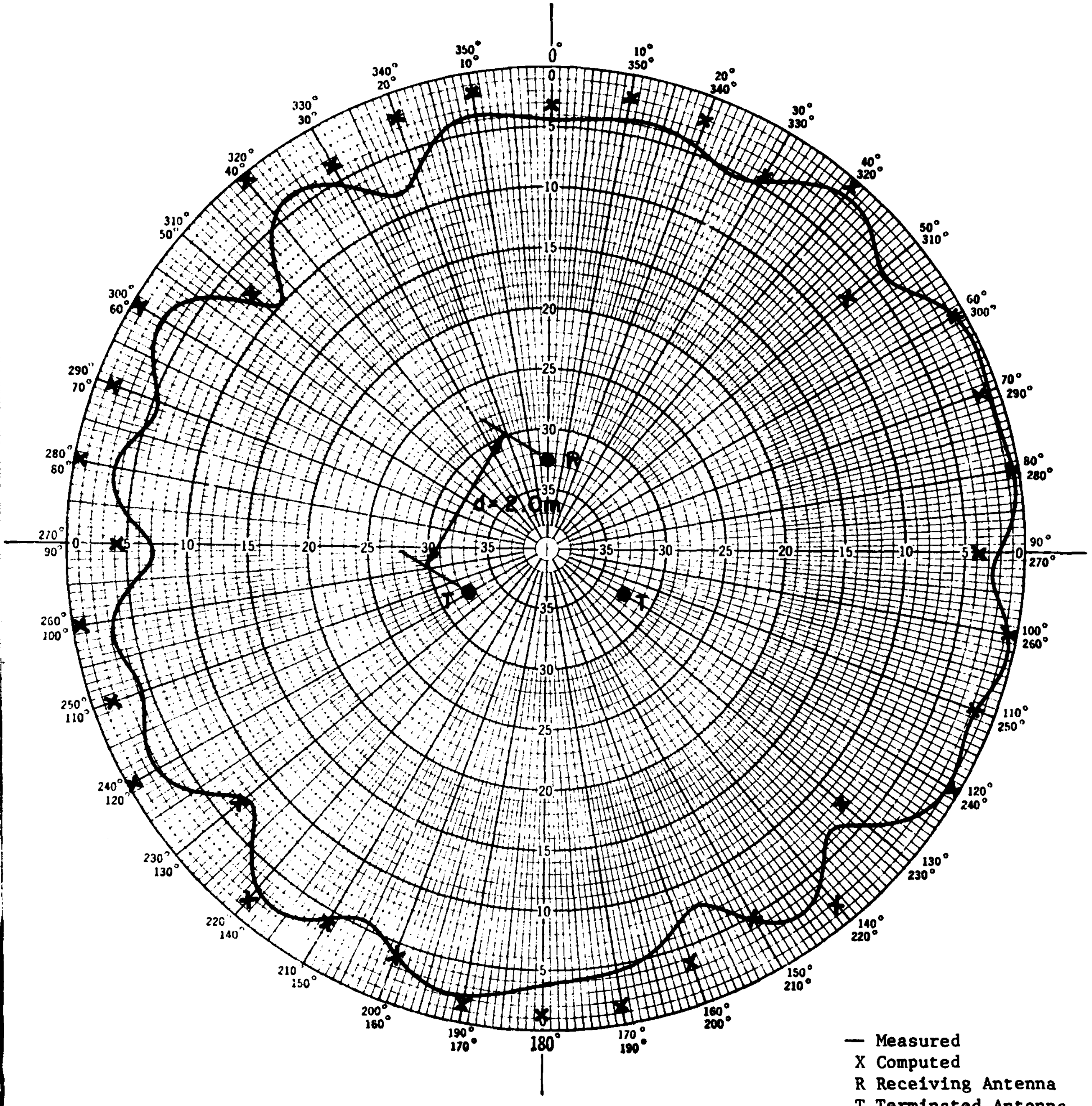


Figure 37. Three AS-1097/GR, f = 400 MHz, d = 2 m, D = 9.75 m

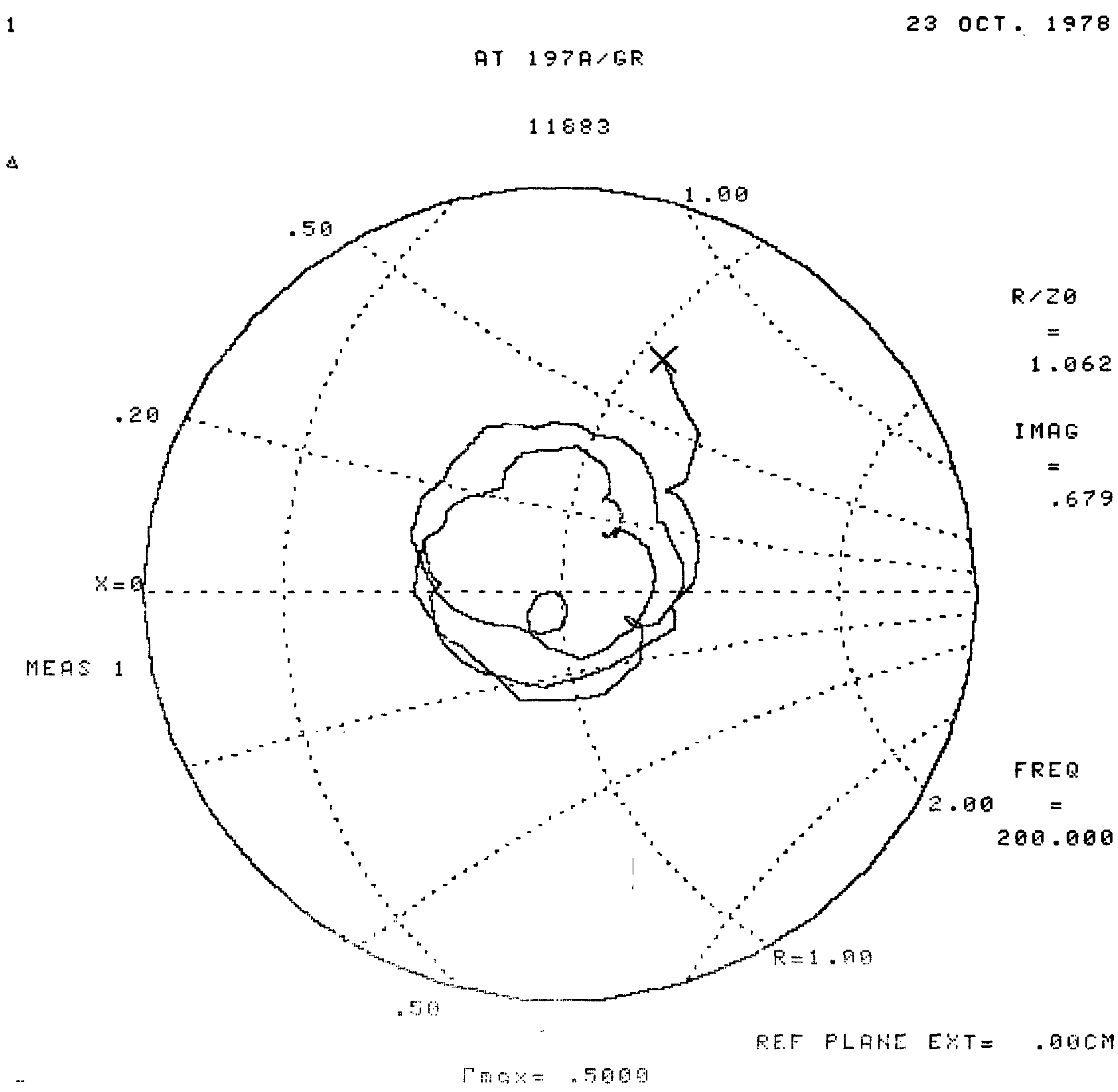


Figure 38. Typical VSWR Plot of an AT-197/GR

5.2 Using only one antenna illuminating at 9.75 m, tests were conducted to probe the illumination field. The results are shown in Figures 39 to 47 with Table IV summarizing the data.

Table IV

Maximum Deviation (± dB) from Circle
for the two AT-197/GR Setup

D = 9.75 m Separation	Frequency (MHz) 250	325	400
1.0 m	0.75	1.25	0.75
1.5 m	1.5	2.0	1.25
2.0 m	2.5	3.0	1.00

5.3 Next, two AT-197/GR Antennas were positioned with separations of 1, 1.5 and 2.0 m. One of the atennas was terminated with a 50 ohm load and the radiation pattern of the other recorded. Using the DISTORT program, corresponding patterns were computed and are shown on the same plots as "x's" in Figures 48 to 56.

5.4 The agreement of the measured and calculated patterns, although in most cases within the expected accuracy of Table IV, were not as good as those shown for the AS-1097/GR. In particular, for the frequency of 400 MHz the model has a problem. This must be related to the number of subsections used in the model. This problem can be corrected now that measured data is available to compare with.

6.0 AT-197/GR MEASUREMENTS - THREE ANTENNAS.

6.1 The same procedure as used for the AS-1097/GR was followed here. Figure 57 shows a photograph of the anechoic chamber with three AT-197/GR Antennas mounted on the measurement setup which is an equilateral triangle with sides that can be set at 1, 1.5 or 2 m.

6.2 Using only one antenna illuminating at D = 8.54 m, tests were conducted to probe the illumination field and are shown in Figures 58 to 66 with Table V summarizing the results.

Table V

Maximum Deviation (± dB) from Circle
for the three AT-197/GR Setup

D = 8.54 m Separation	Frequency (MHz) 250	325	400
1.0 m	1.0	1.0	1.5
1.5 m	1.25	2.5	1.25
2.0 m	2.0	4.5	1.75

6.3 Next, three AT-197/GR Antennas were mounted at the vertices of the equilateral triangle, two terminated with 50 ohms, and the pattern of the third was recorded. The results are shown in Figures 67 to 75. Again, the "x's" correspond to the calculated values from DISTORT.

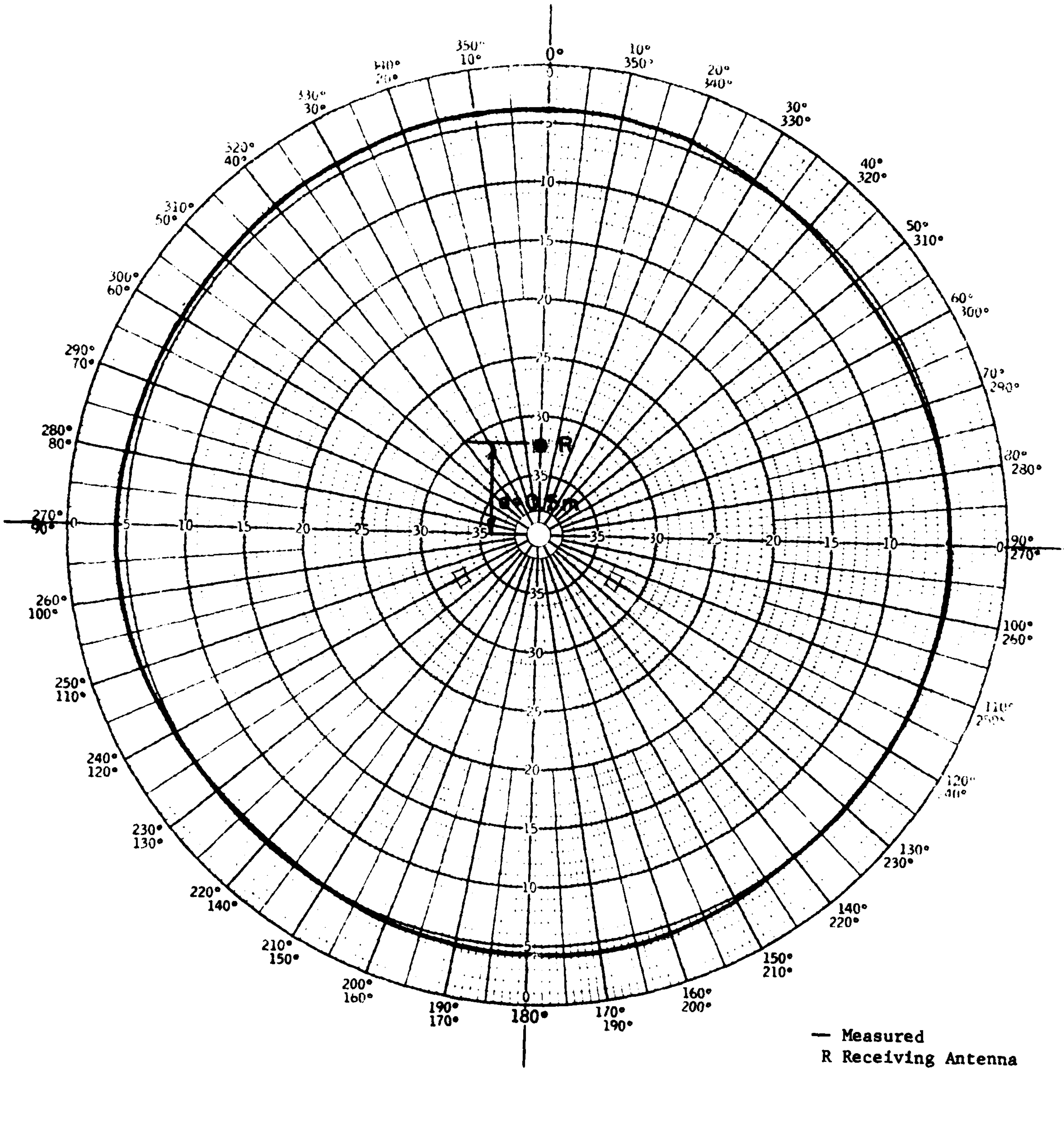


Figure 39. One AT-197/GR, f = 250 MHz, d = 1 m for Two Antenna Setup, D = 9.75 m

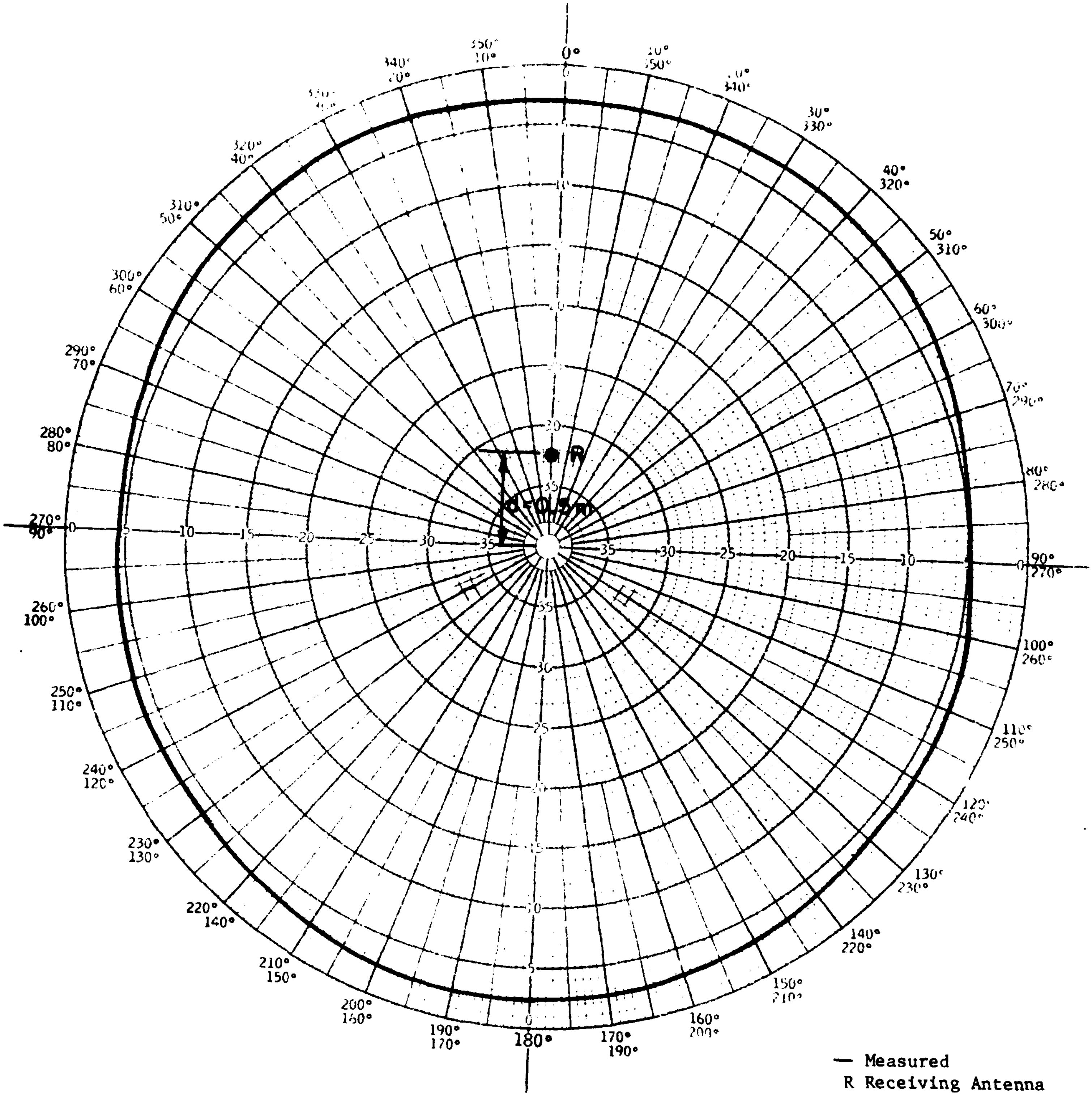


Figure 40. One AT-197/GR, f = 325 MHz, d = 1 m for Two Antenna Setup, D = 9.75 m

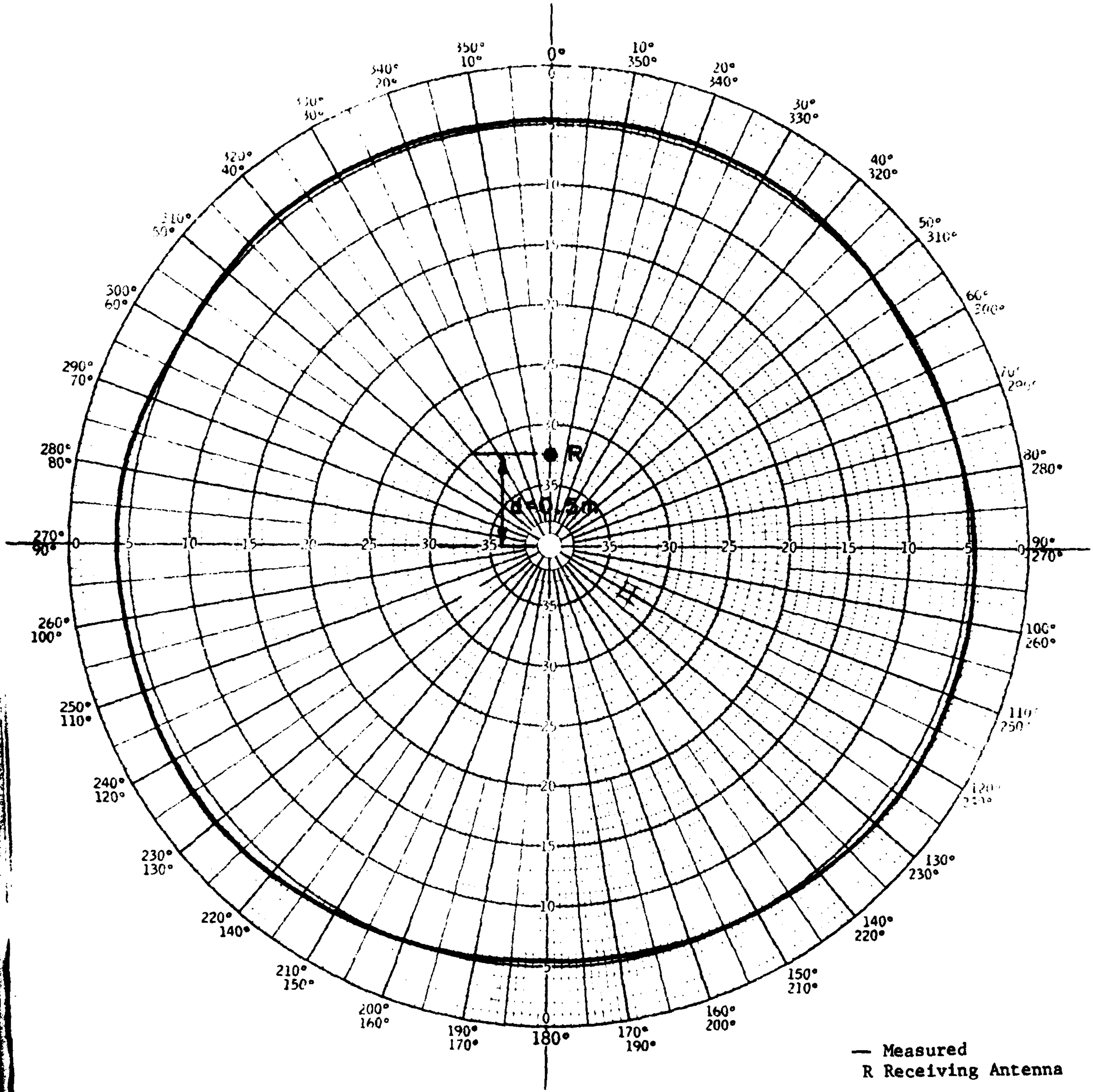


Figure 41. One AT-197/GR, f = 400 MHz, d = 1 m for Two Antenna Setup, D = 9.75 m

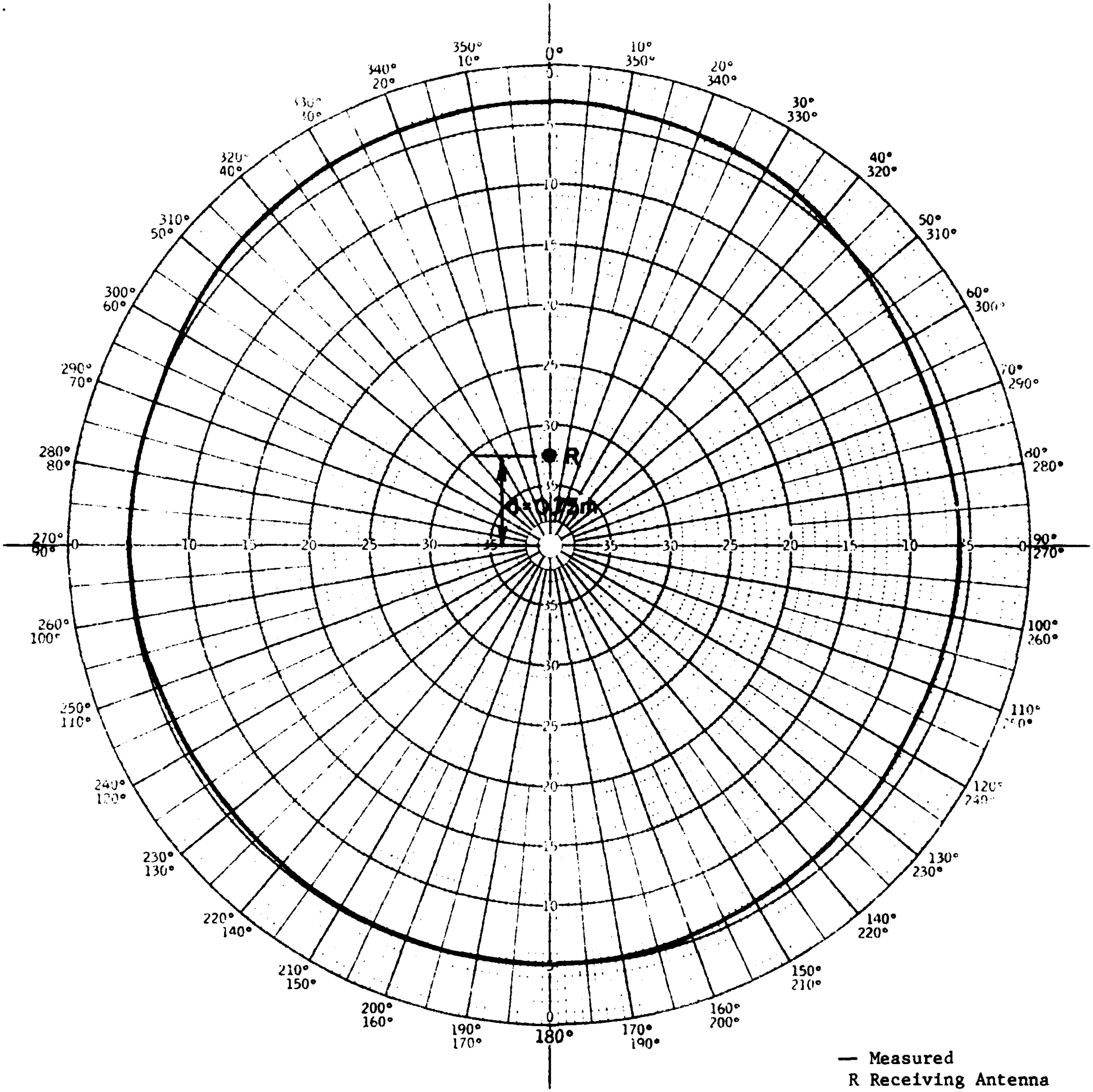


Figure 42. One AT-197/GR, f = 250 MHz, d = 1.5 m for Two Antenna Setup, D = 9.75 m

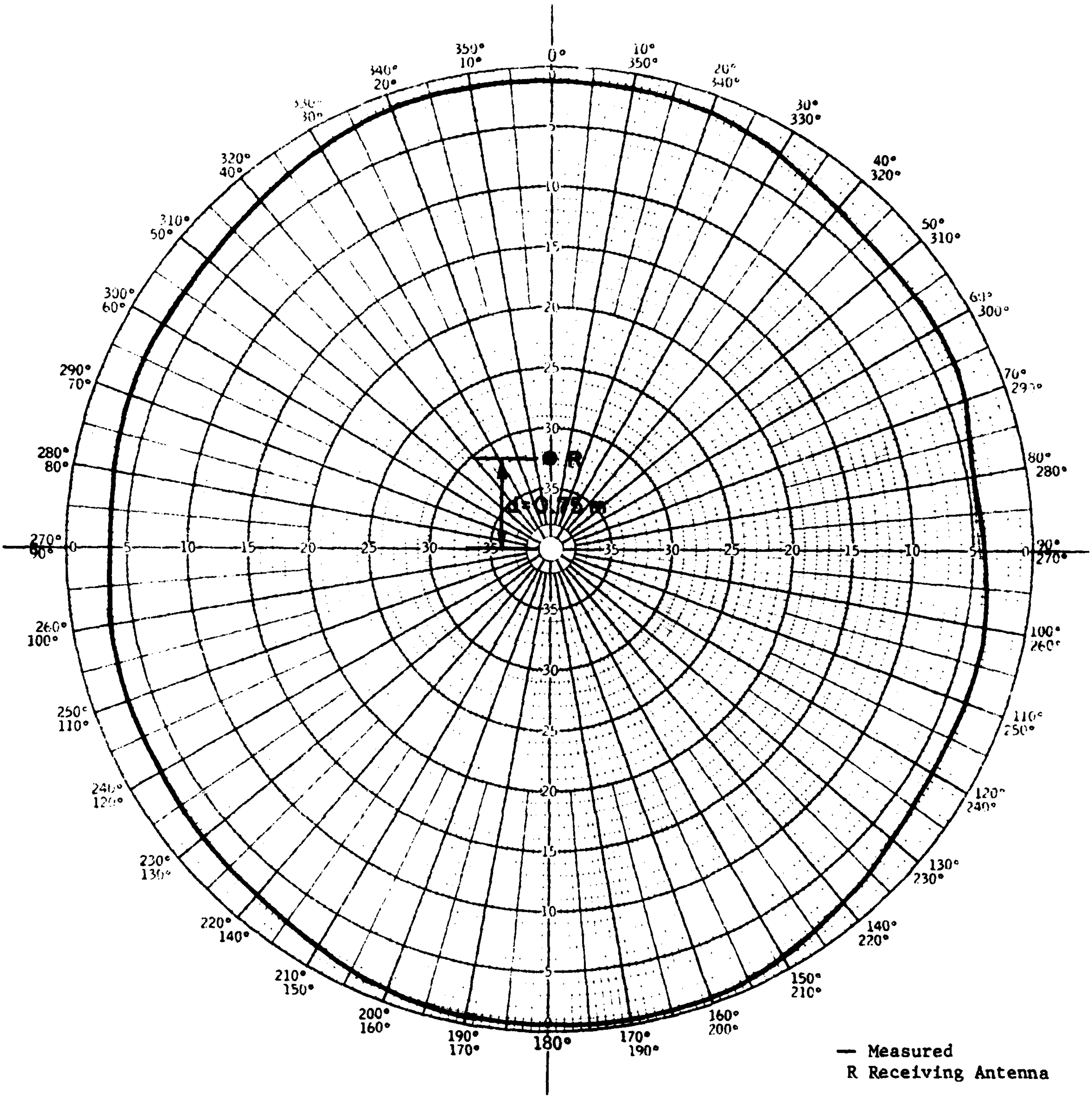


Figure 43. One AT-197/GR, f = 325 MHz, d = 1.5 m for Two Antenna Setup, D = 9.75 m

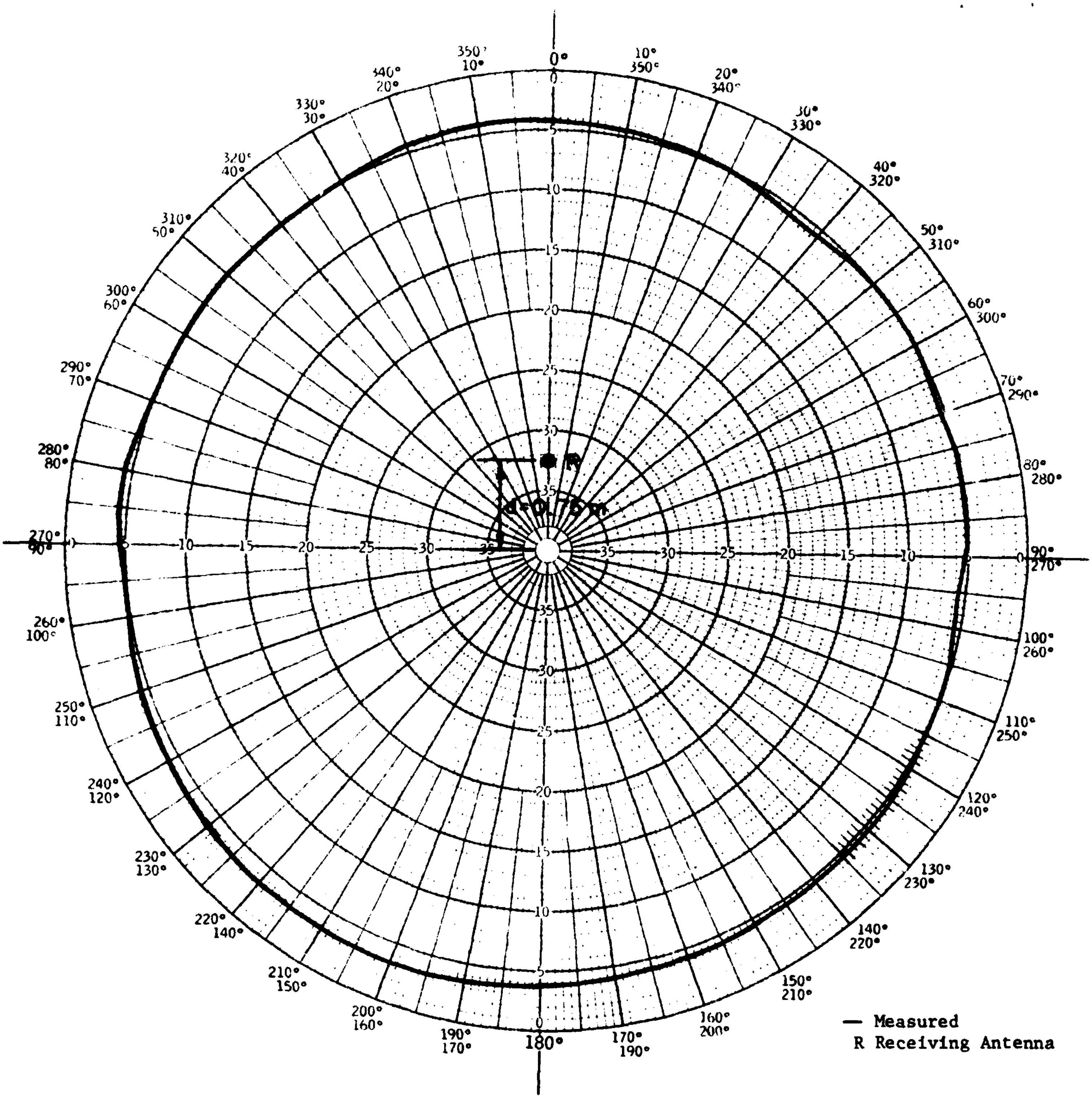
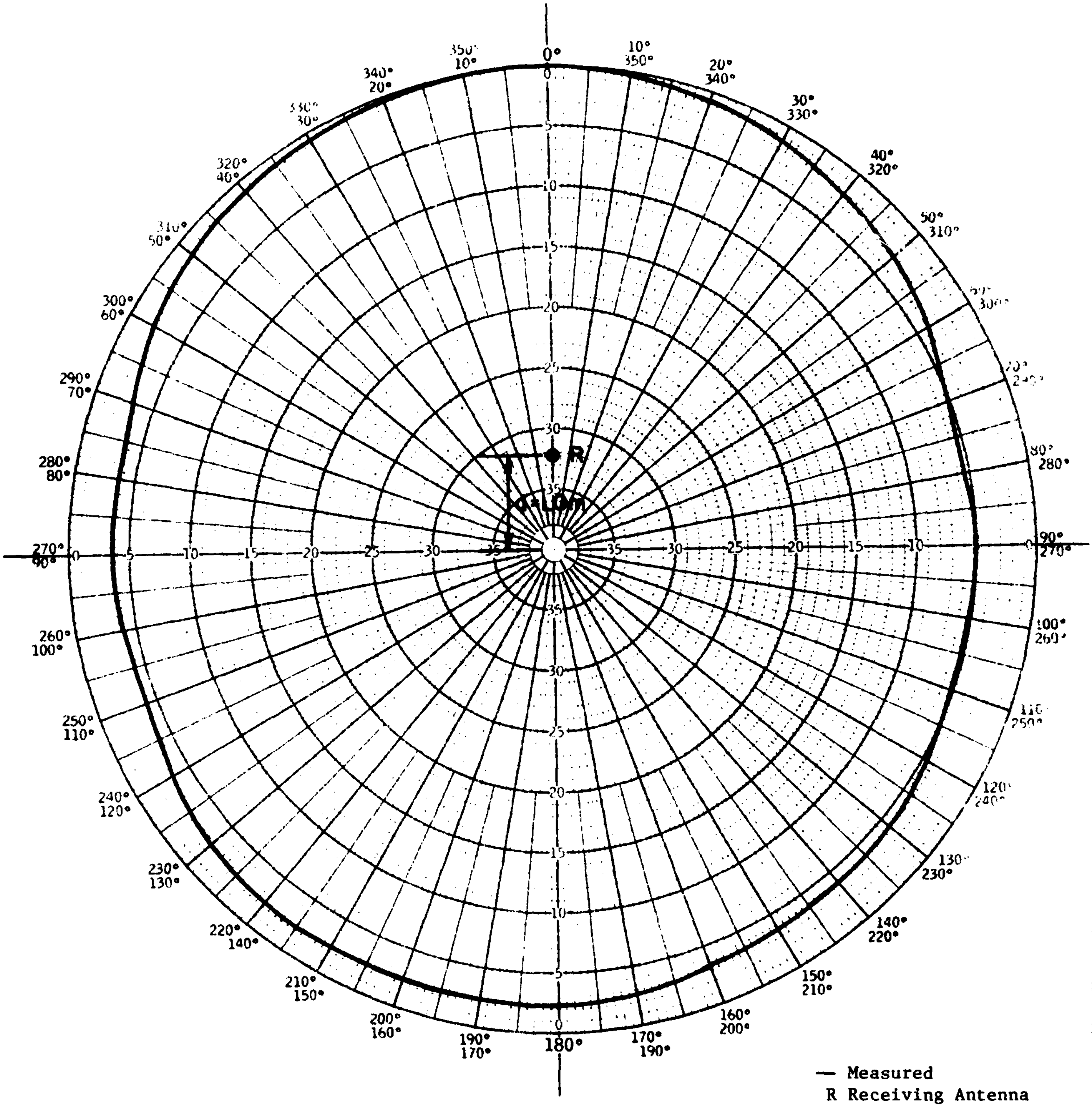


Figure 44. One AT-197/GR, f = 400 MHz, d = 1.5 m for Two Antenna Setup, D = 9.75 m



— Measured
R Receiving Antenna

Figure 45. One AT-197/GR, f = 250 MHz, d = 2 m for Two Antenna Setup, D = 9.75 m

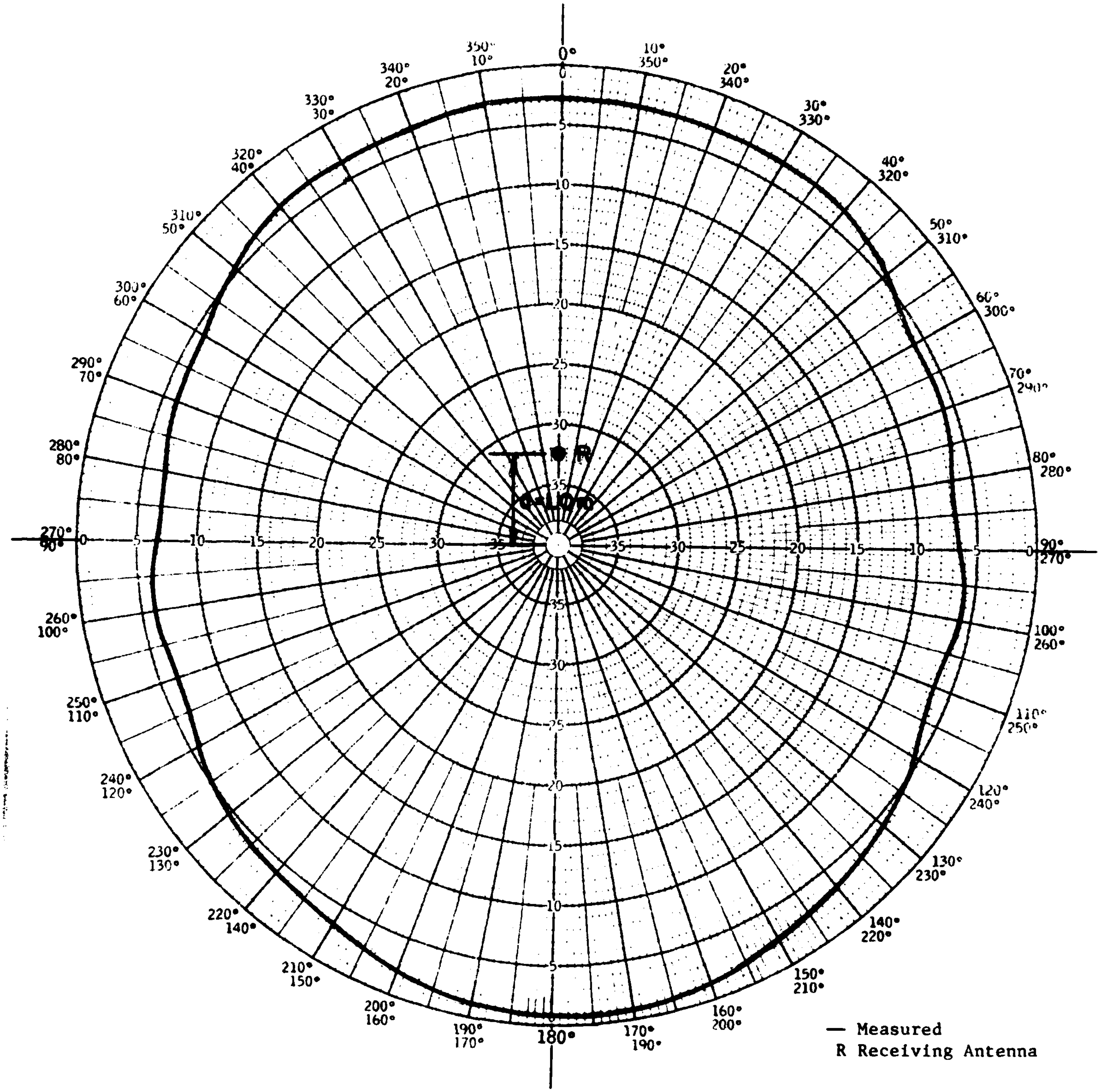


Figure 46. One AT-197/GR, f = 325 MHz, d = 2 m for Two Antenna Setup, D = 9.75 m

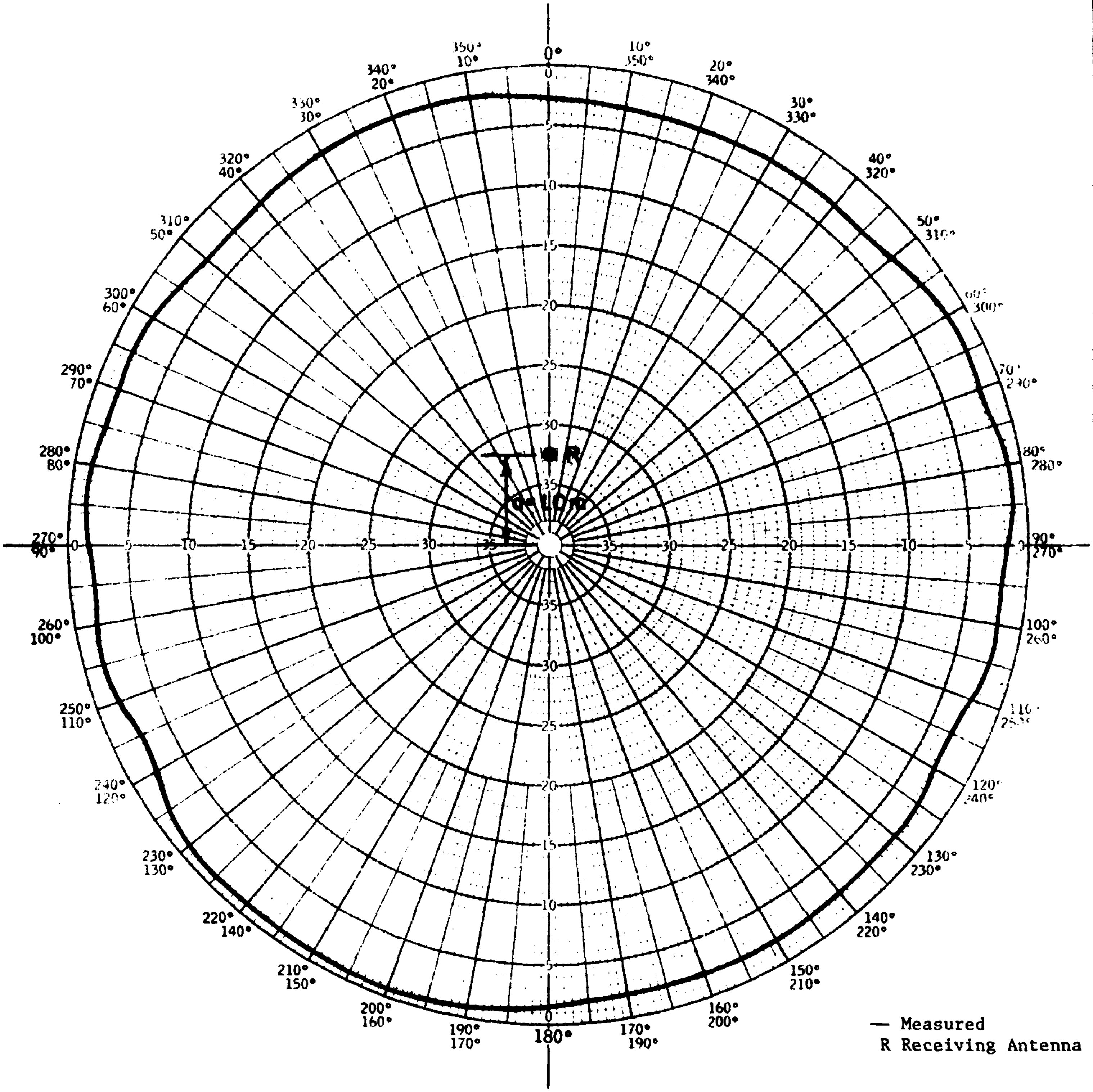
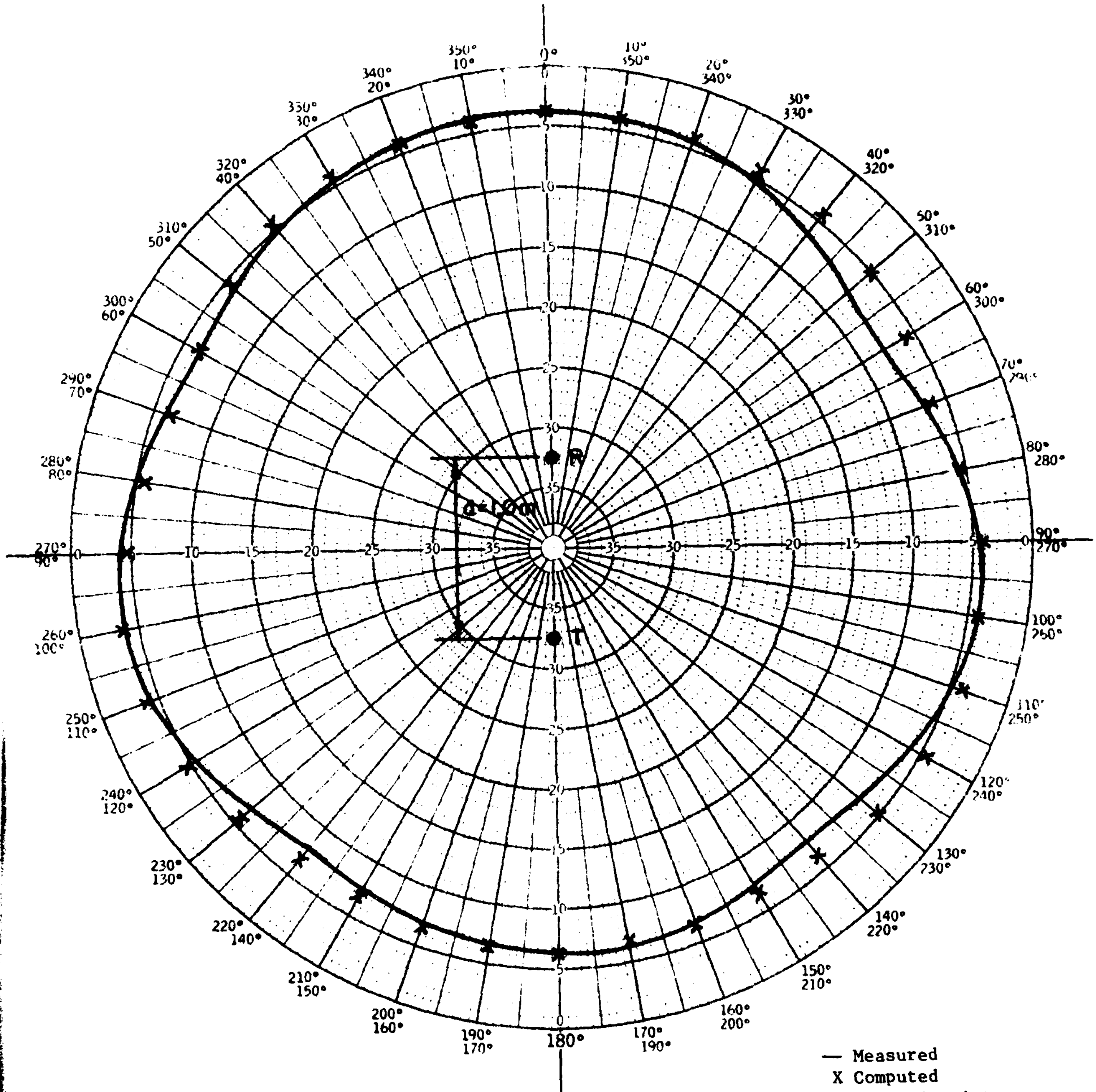


Figure 47. One AT-197/GR, f = 400 MHz, d = 2 m for Two Antenna Setup, D = 9.75 m



— Measured
X Computed
R Receiving Antenna
T Terminated Antenna

Figure 48. Two AT-197/GR, f = 250 MHz, d = 1 m, D = 9.75 m

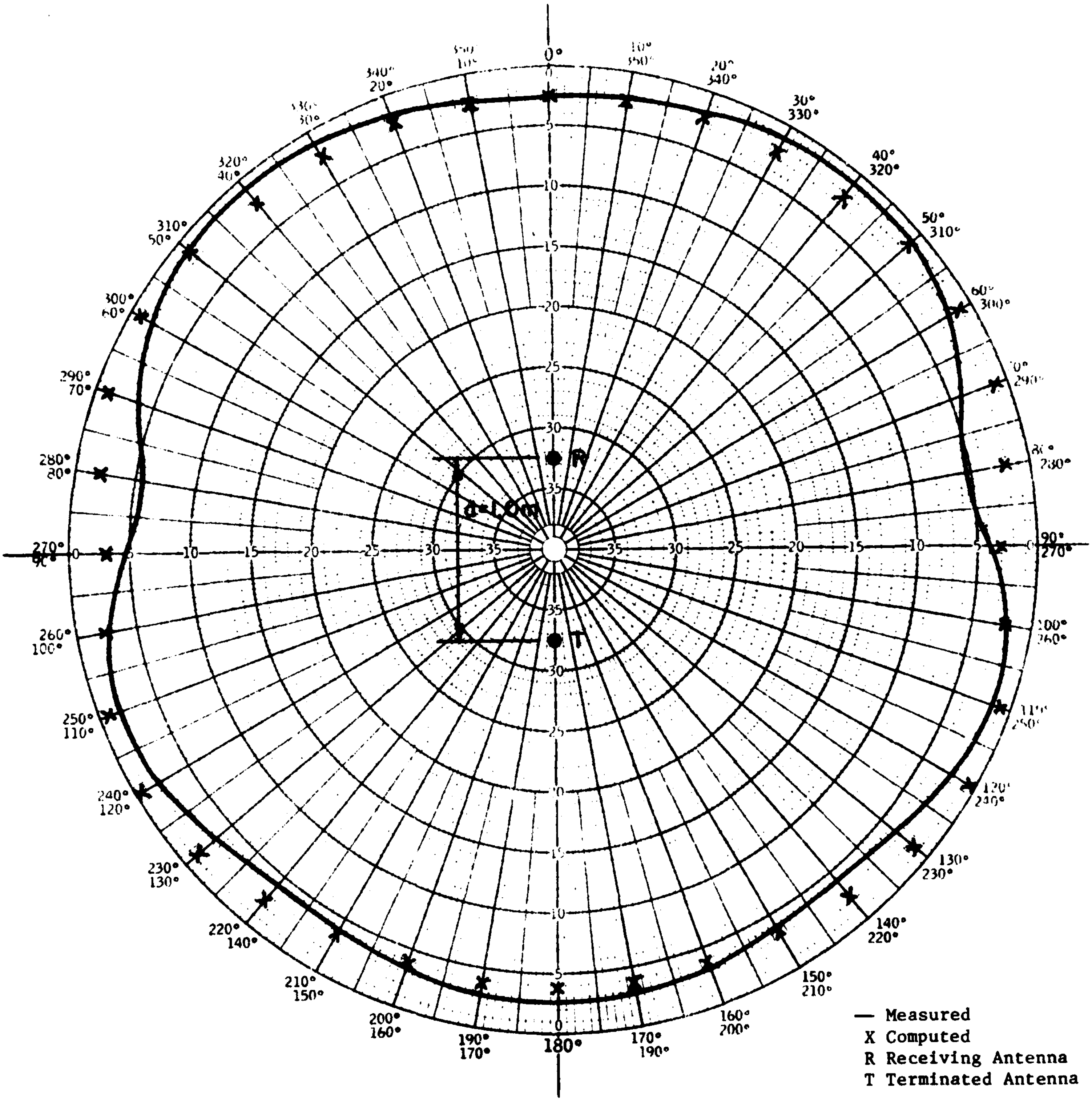


Figure 49. Two AT-197/GR, f = 125 MHz, d = 1 m, D = 9,75 m

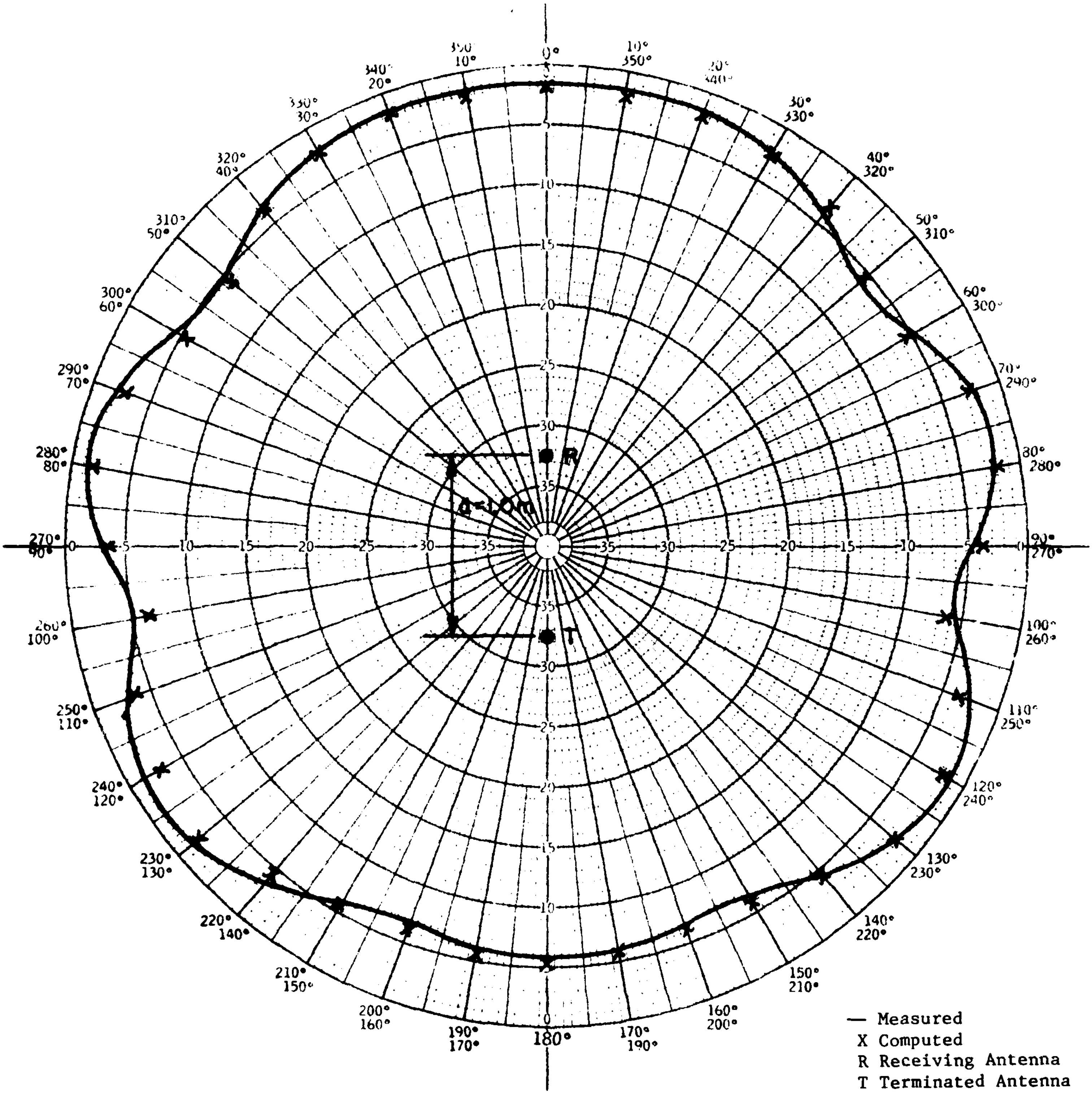


Figure 50. Two AT-197/GR, f = 400 MHz, d = 1 m, D = 9.75 m

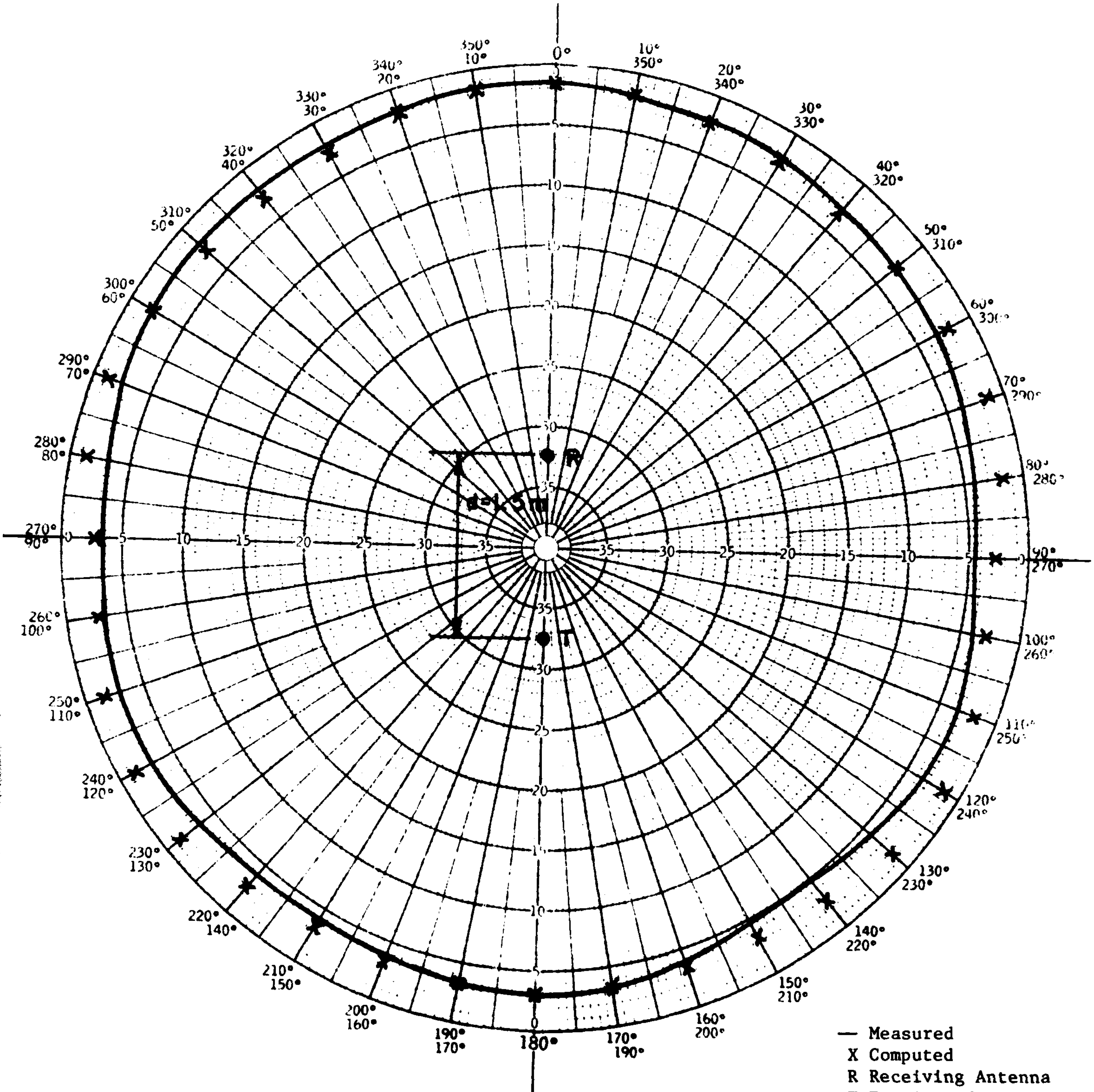


Figure 51. Two AT-197/GR, f = 250 MHz, d = 1.5 m, D = 9.75 m

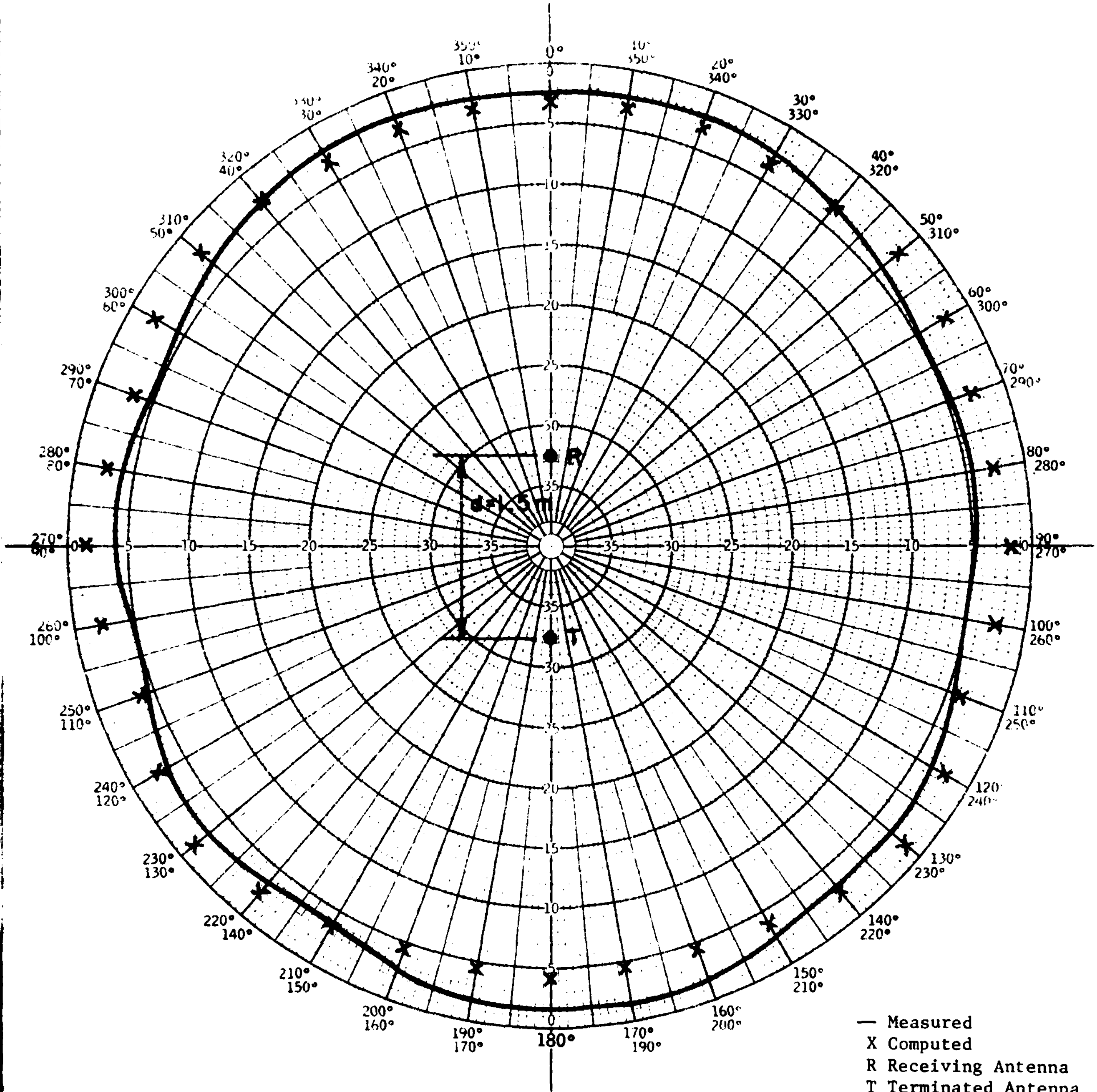


Figure 52. Two AT-197/GR, f = 325 MHz, d = 1.5 m, D = 9.75 m

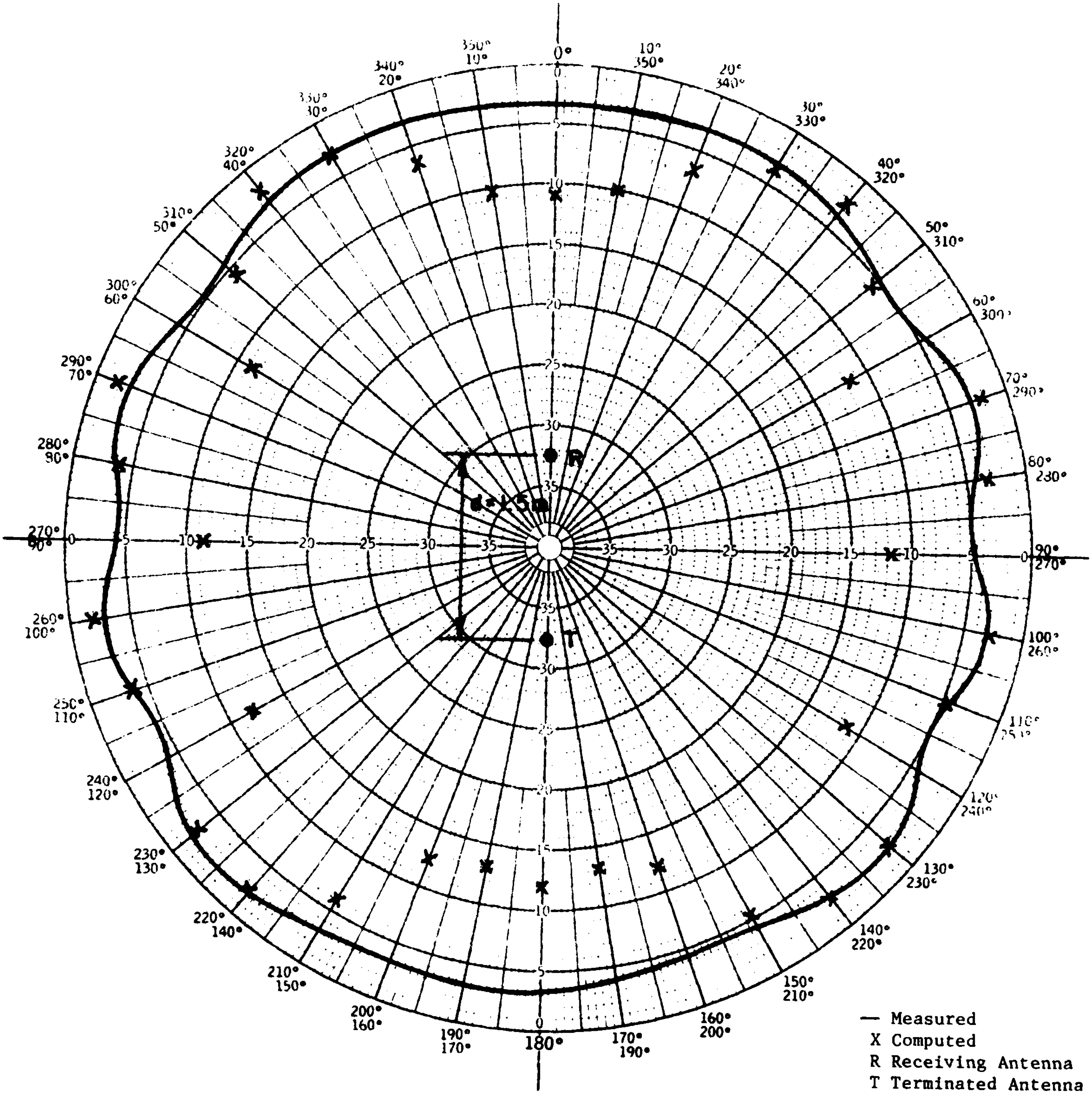


Figure 53. Two AT-197/GR, f = 400 MHz, d = 1.5 m, D = 9.75 m

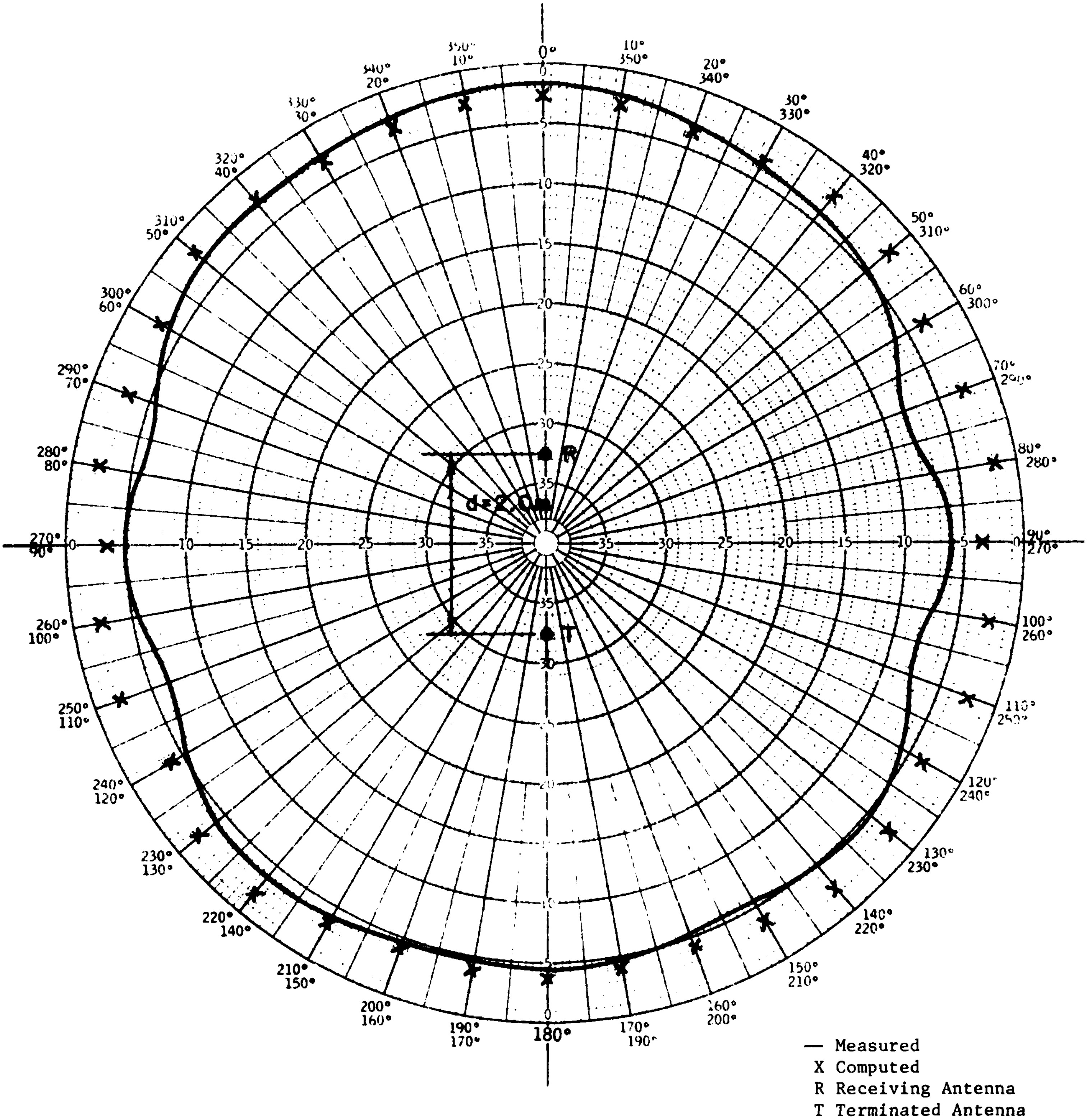


Figure 54. Two AT-197/GR, f = 250 MHz, d = 2 m, D = 9.75 m

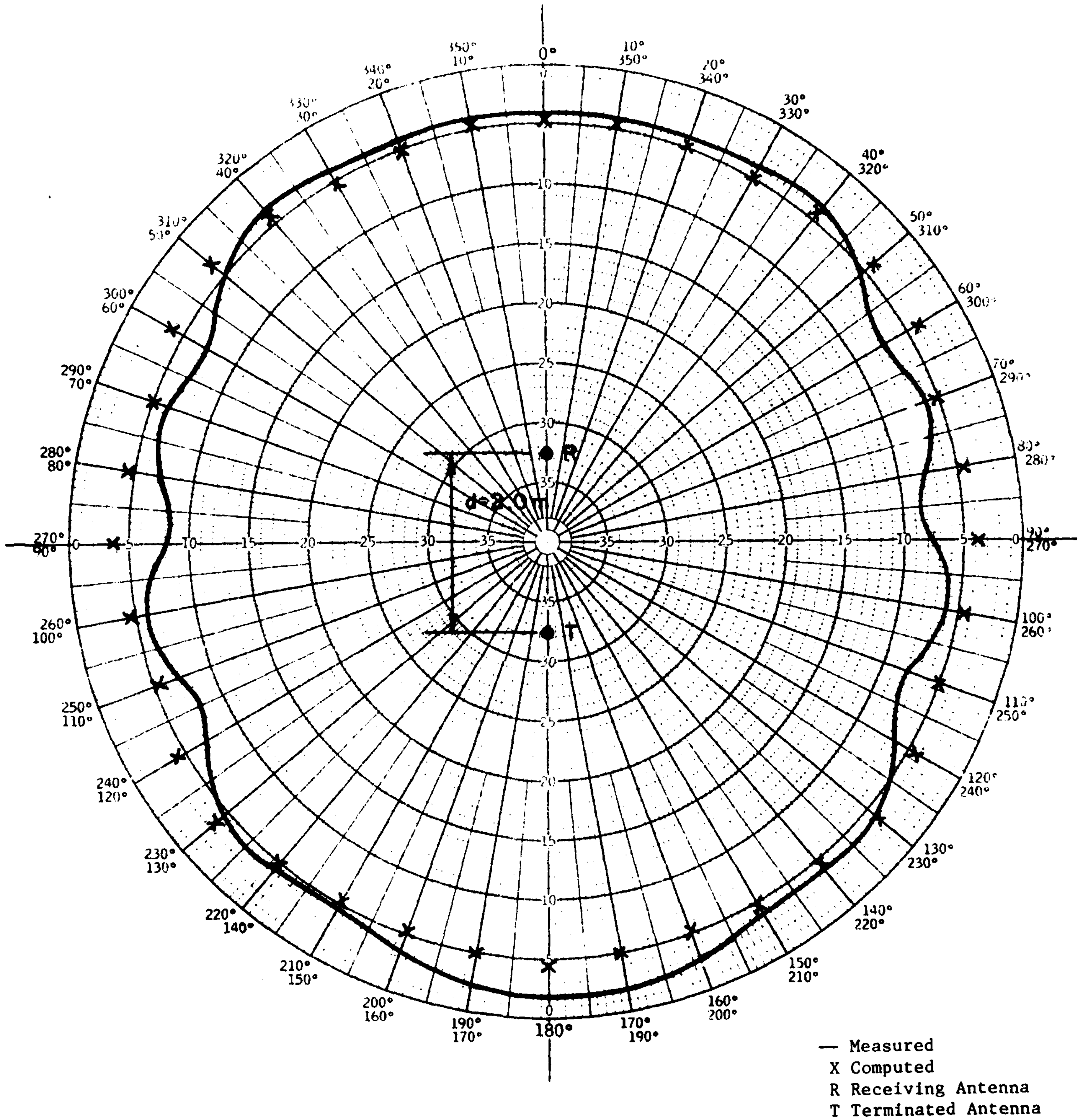


Figure 55. Two AT-197/GR, f = 325 MHz, d = 2 m, D = 9.75 m

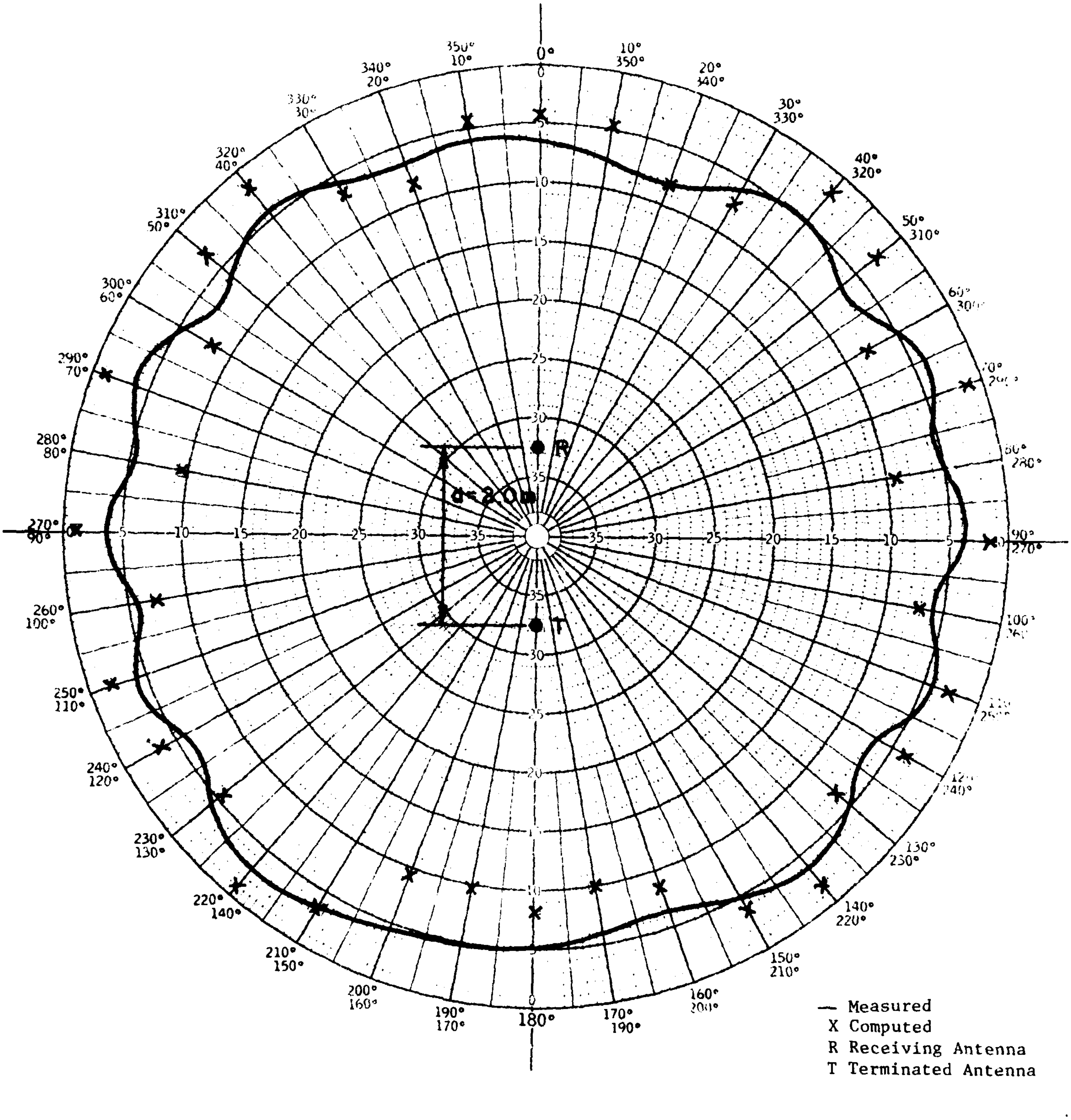


Figure 56. Two AT-197/GR, f = 400 MHz, d = 2 m, D = 9.75 m

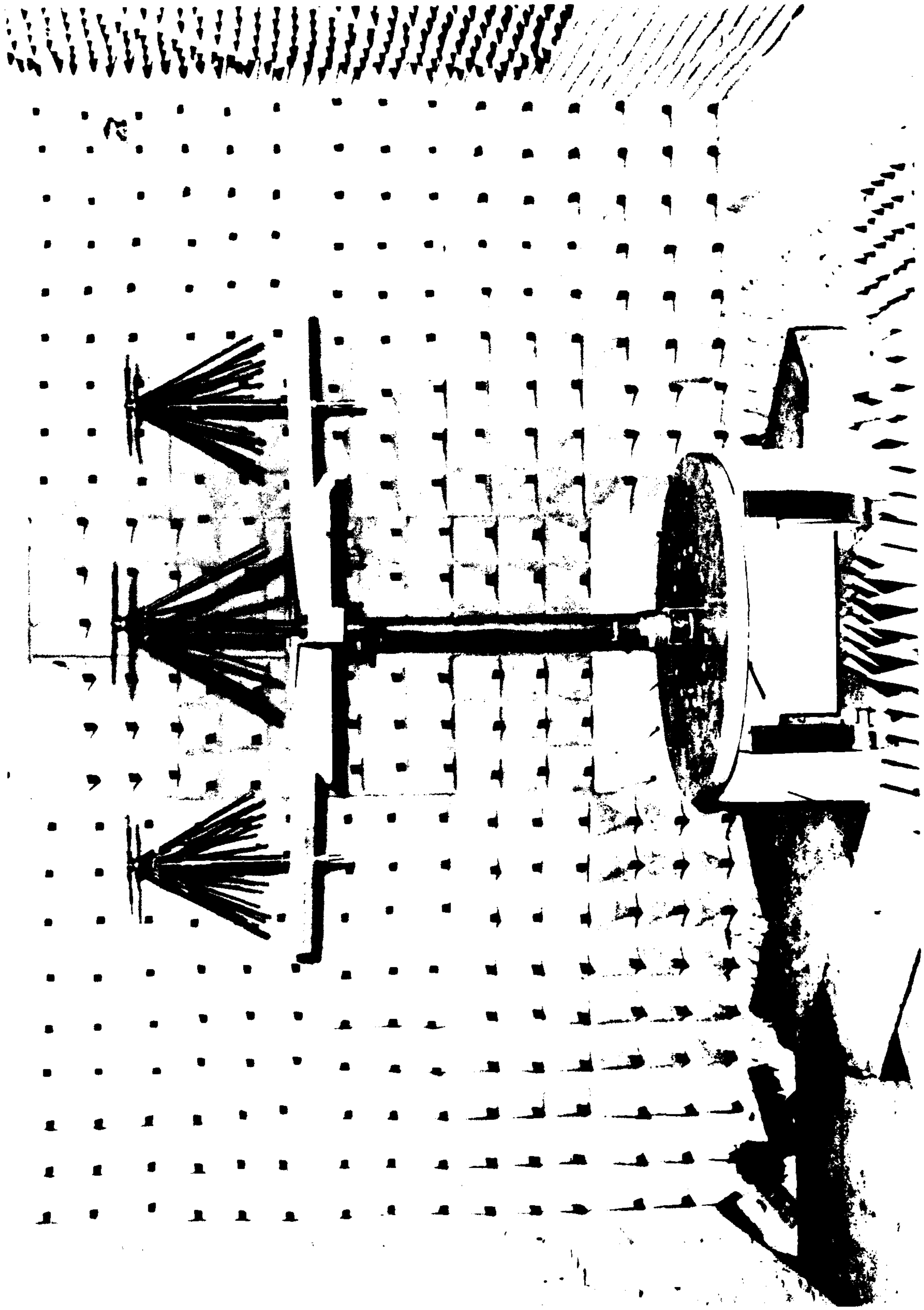


Figure 57. Anechoic Chamber Setup for Three AT-197/GR Measurements

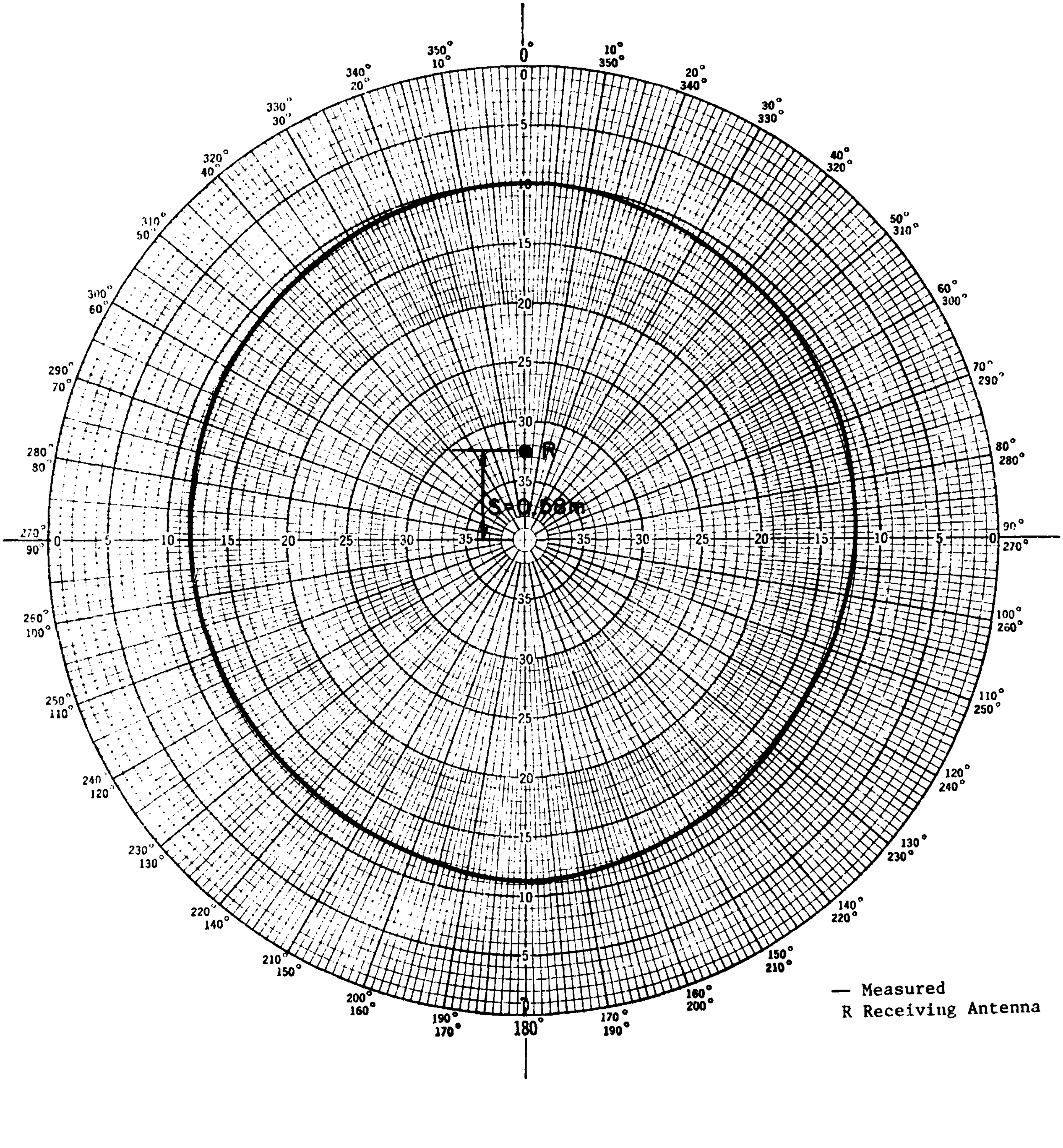


Figure 58. One AT-197/GR, f = 250 MHz, d = 1 m for Three Antenna Setup, D = 8.54 m

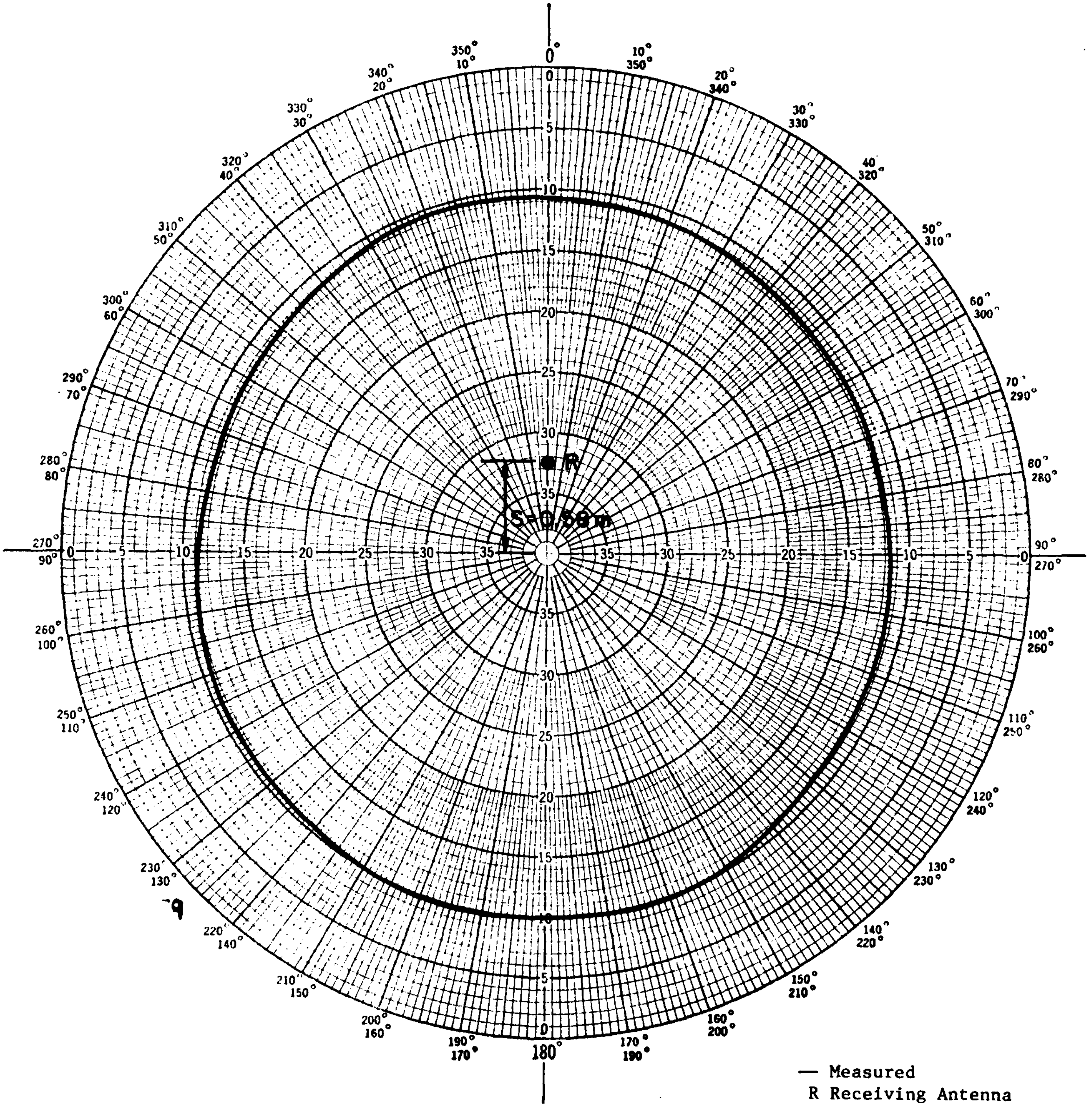
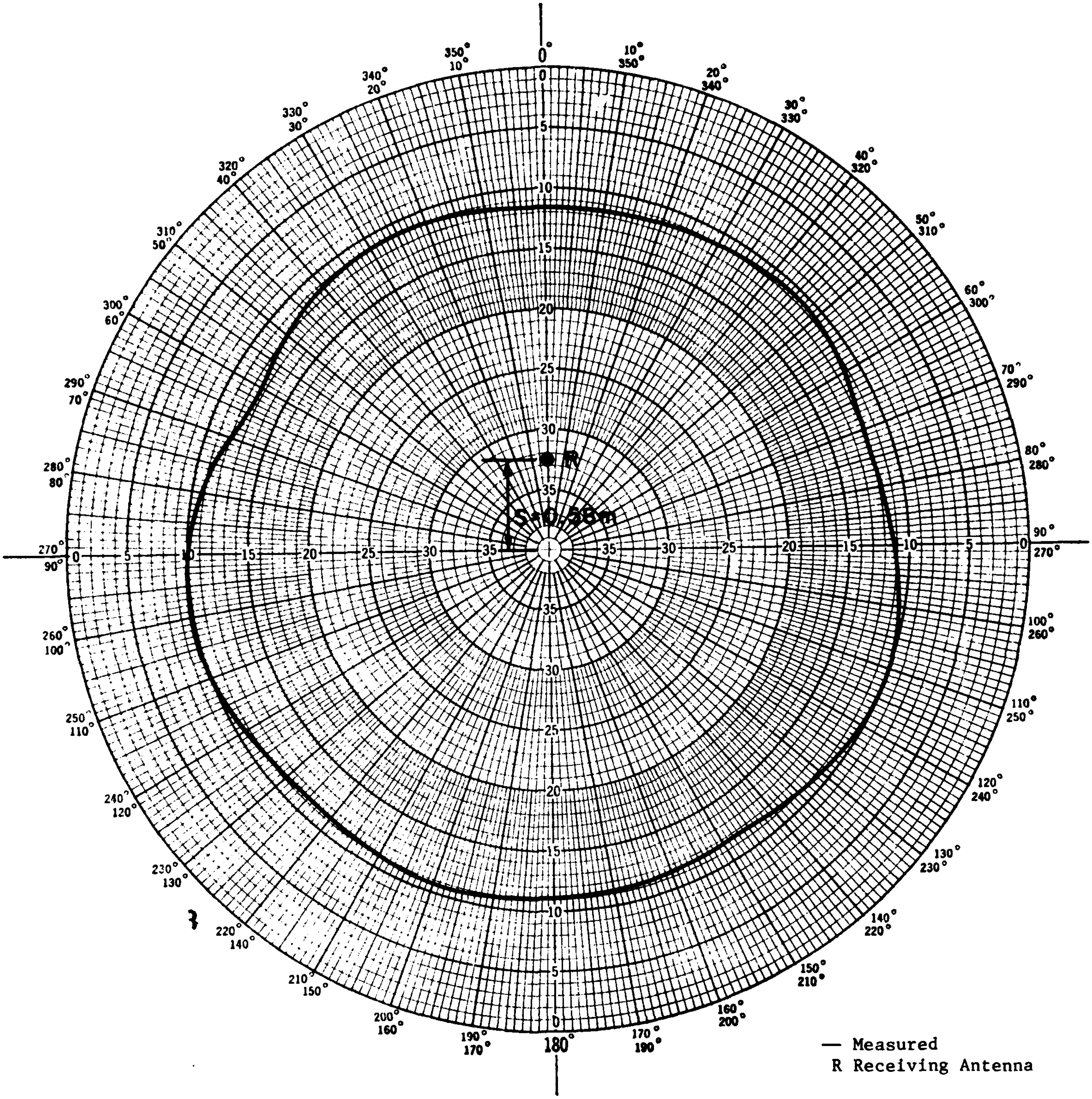


Figure 59. One AT-197/GR, f = 325 MHz, d = 1 m for Three Antenna Setup, D = 8.54 m



— Measured
R Receiving Antenna

Figure 60. One AT-197/GR, f = 400 MHz, d = 1 m for Three Antenna Setup, D = 8.54 m

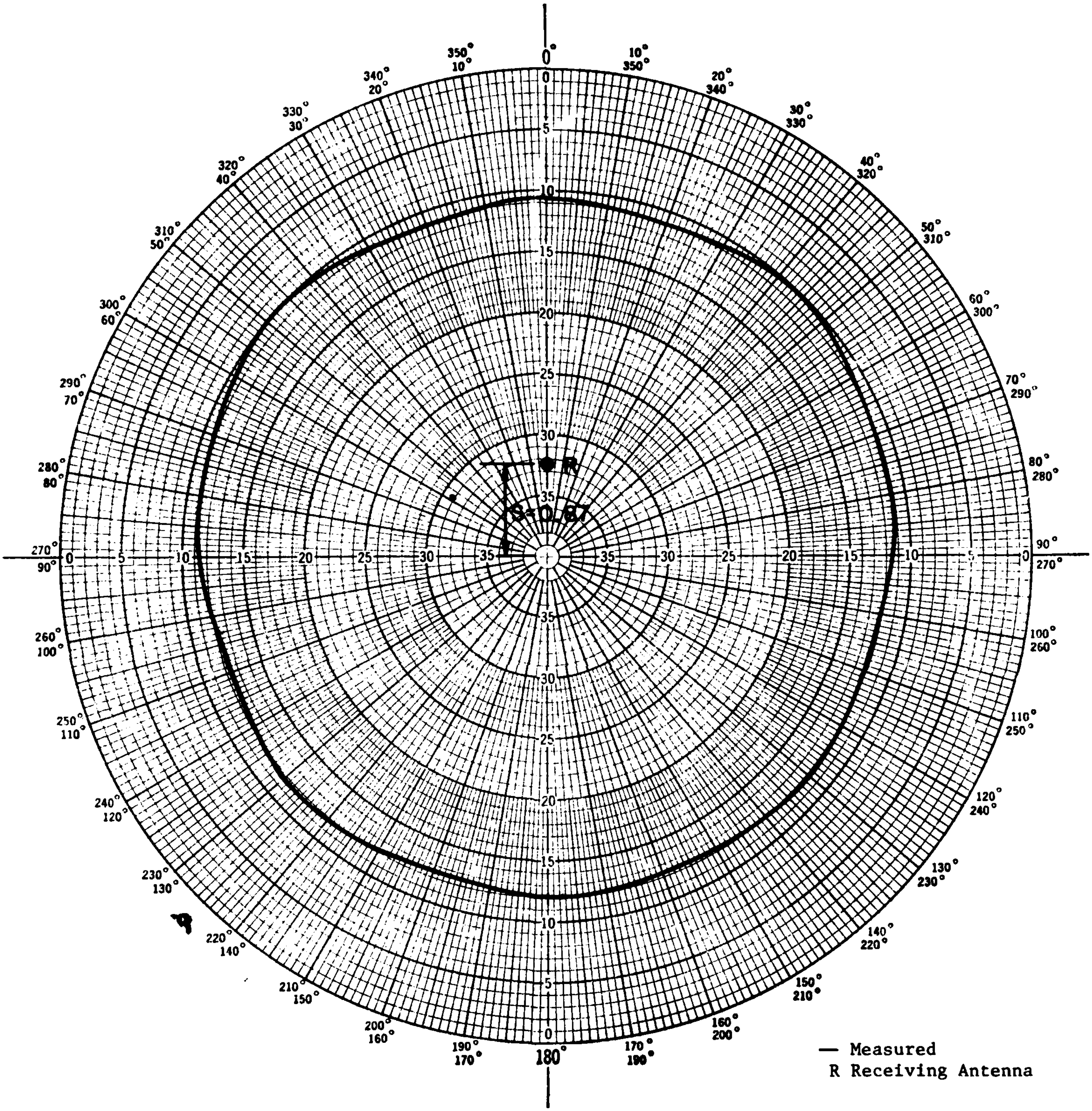


Figure 61. One AT-197/GR, f = 250 MHz, d = 1.5 m for Three Antenna Setup, D = 8.54 m

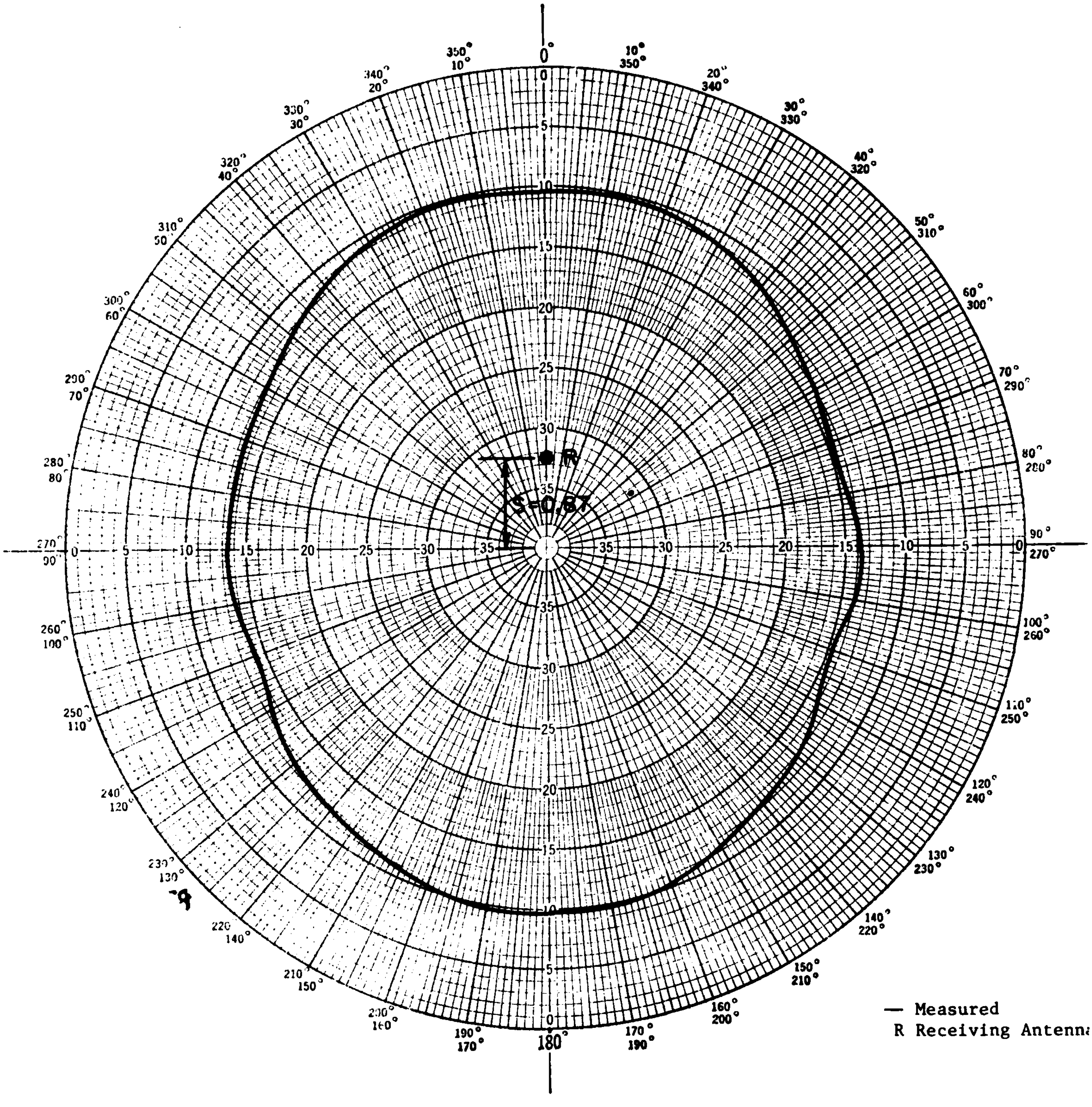


Figure 62. One AT-197/GR, f = 325 MHz, d = 1.5 m for Three Antenna Setup, D = 8.54 m

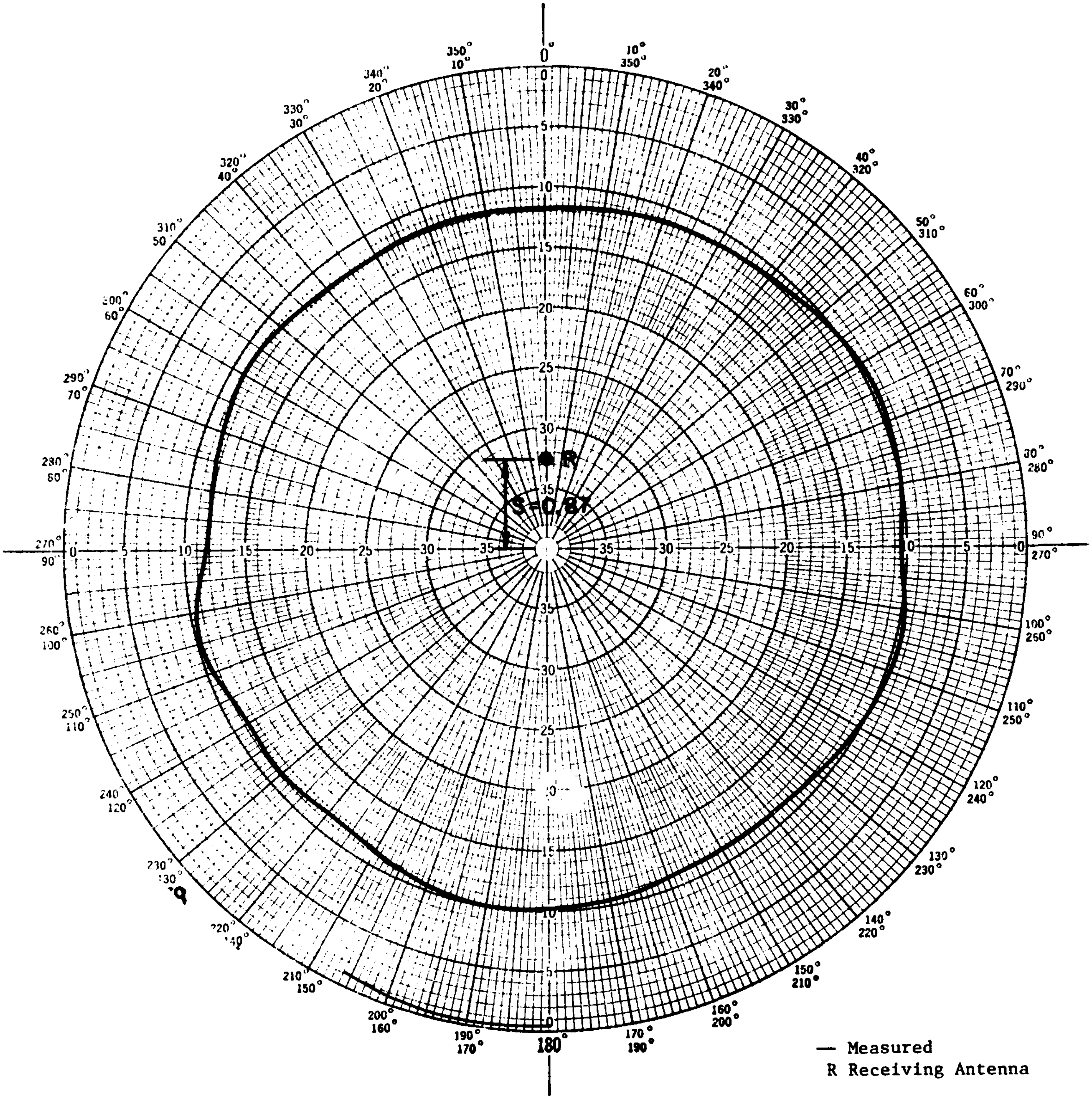


Figure 63. One AT-197/GR, f = 400 MHz, d = 1.5 m for Three Antenna Setup, D = 8.54 m

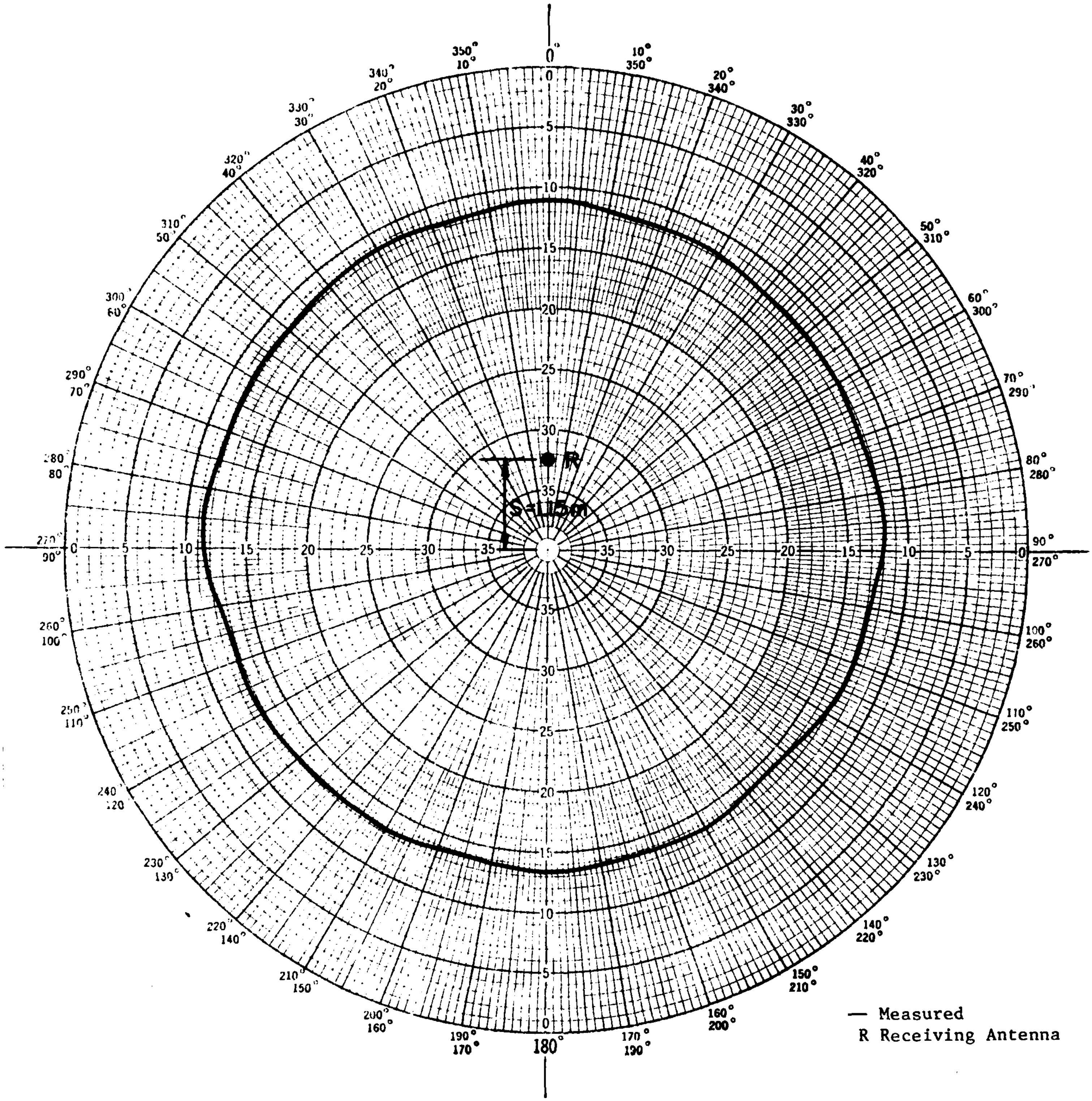


Figure 64. One AT-197/GR, f = 250 MHz, d = 2 m for Three Antenna Setup, D = 8.54 m

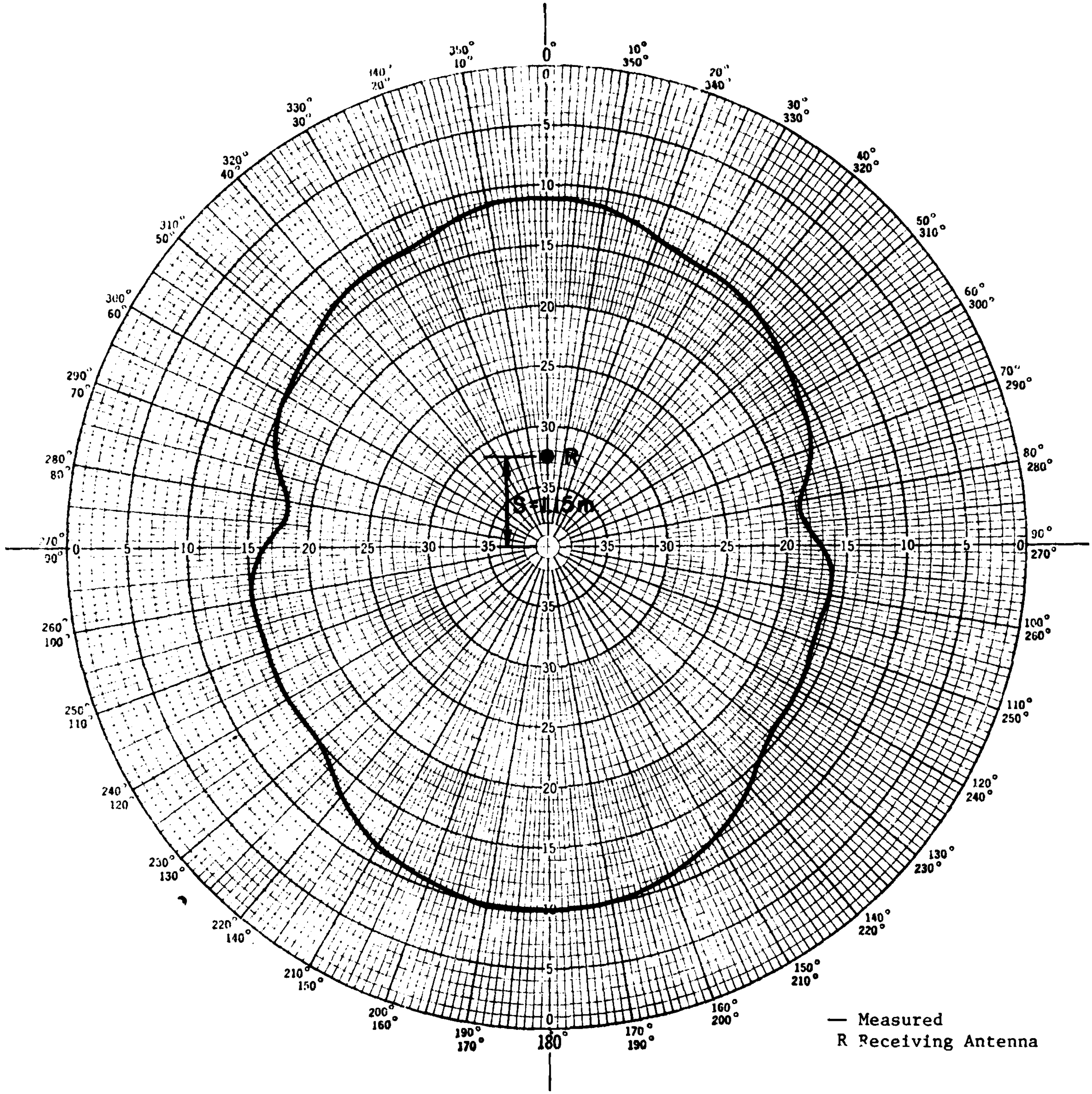


Figure 65. One AT-197/GR, f = 325 MHz, d = 2 m for Three Antenna Setup, D = 8.54 m

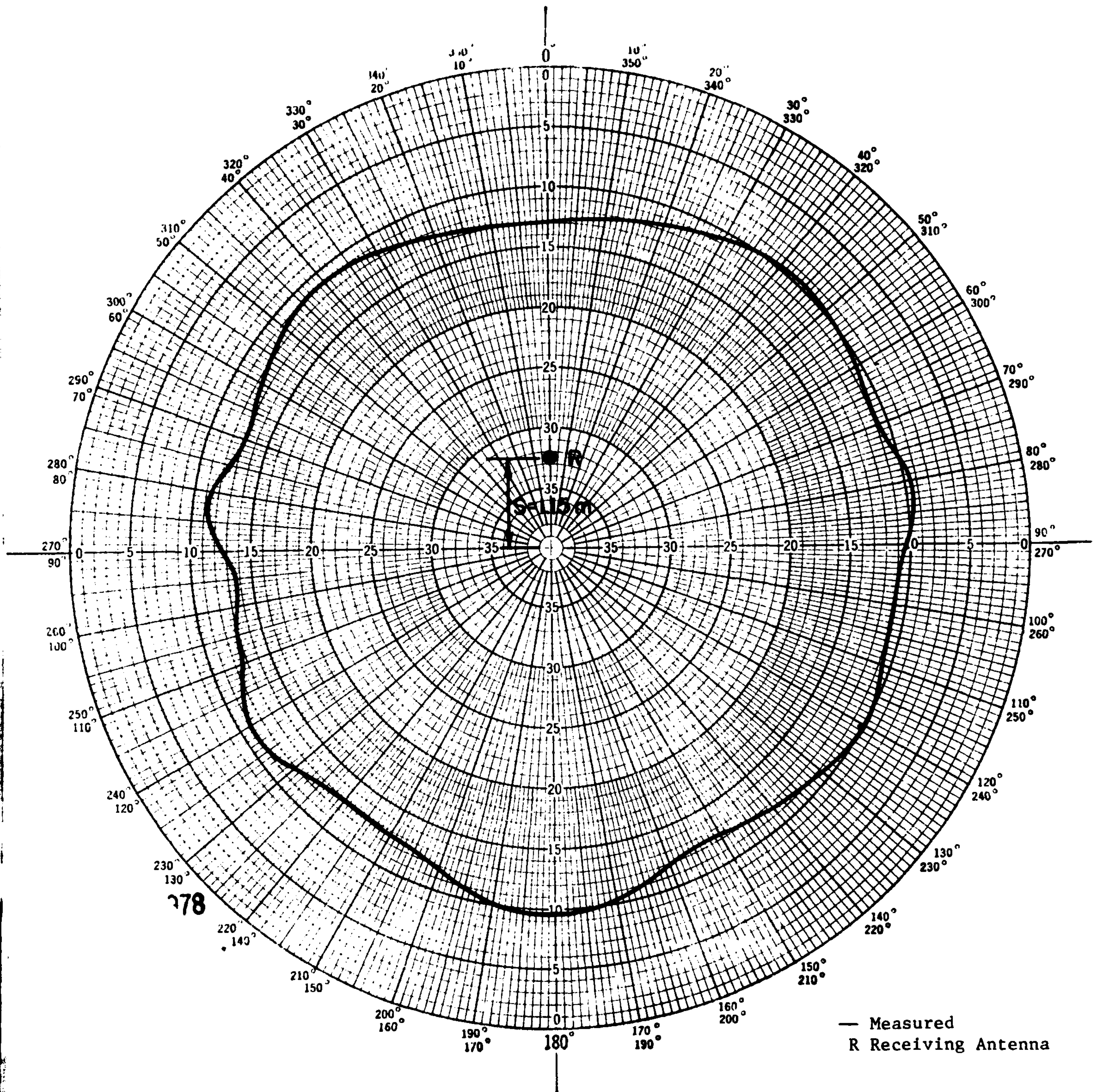


Figure 66. One AT-197/GR, f = 400 MHz, d = 2 m for Three Antenna Setup, D = 8.54 m

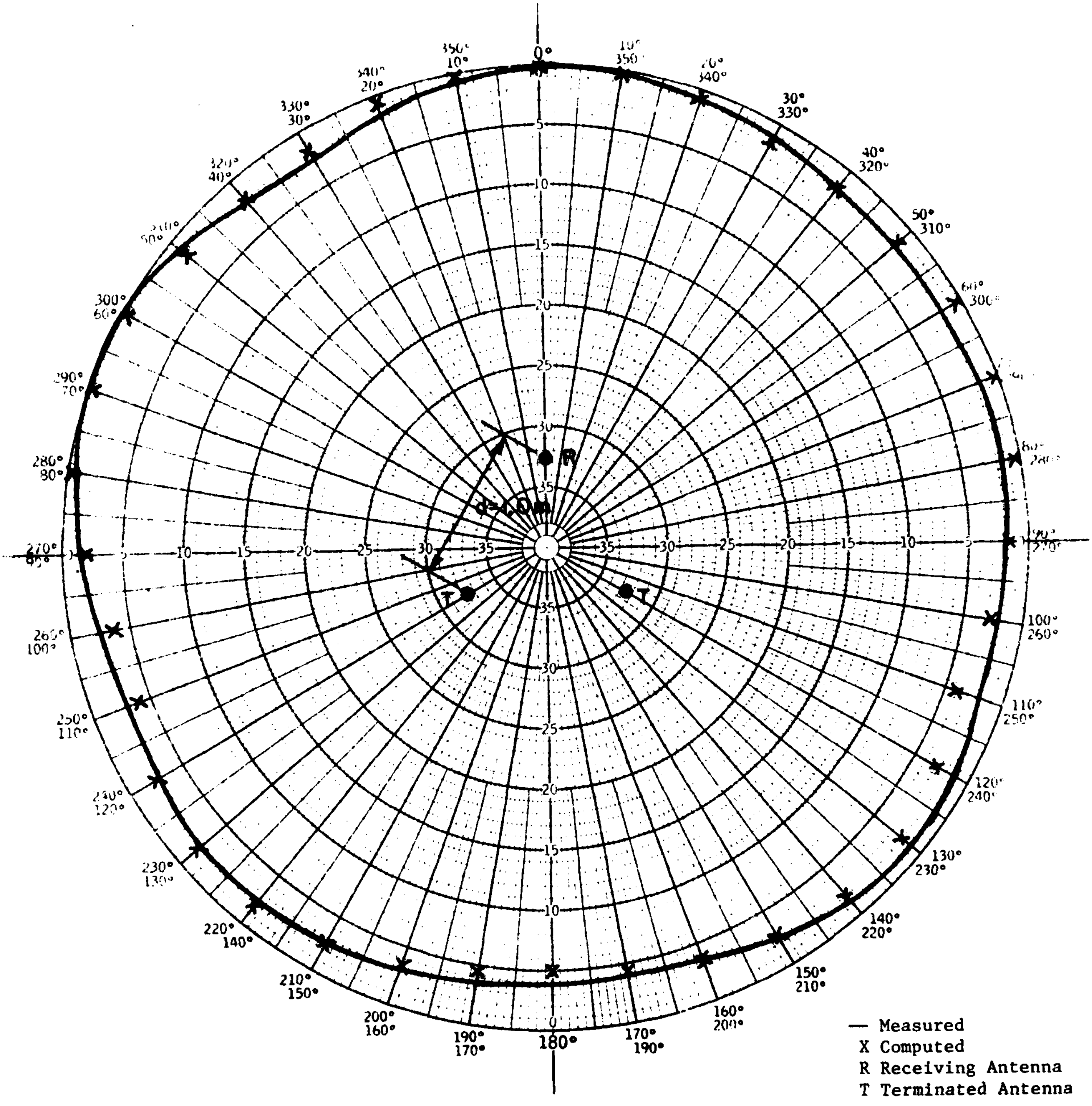


Figure 67. Three AT-197/GR, f = 250 MHz, d = 1 m, D = 8.54 m

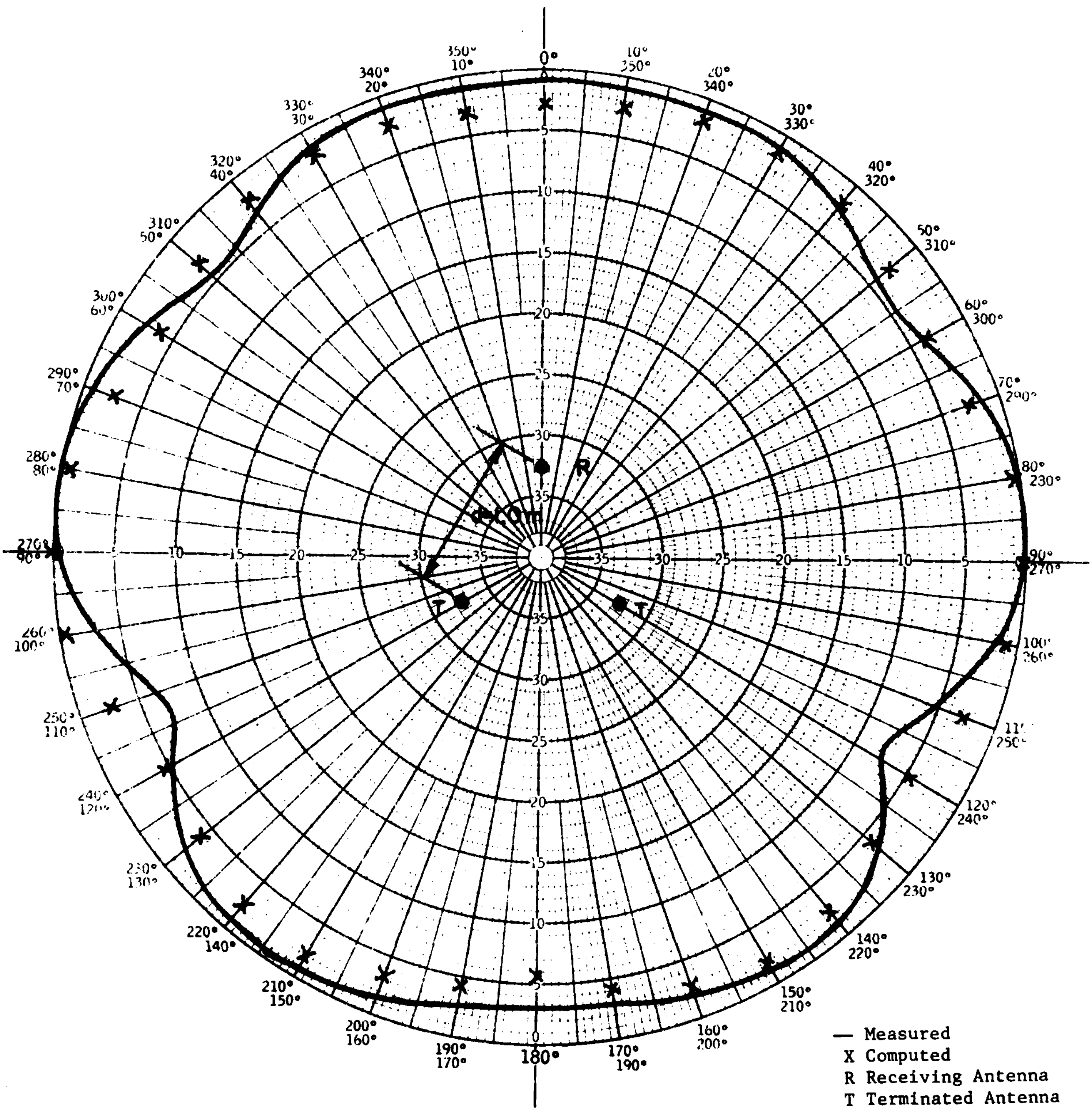


Figure 68. Three AT-197/GR, f = 325 MHz, d = 1 m, D = 8.54 m

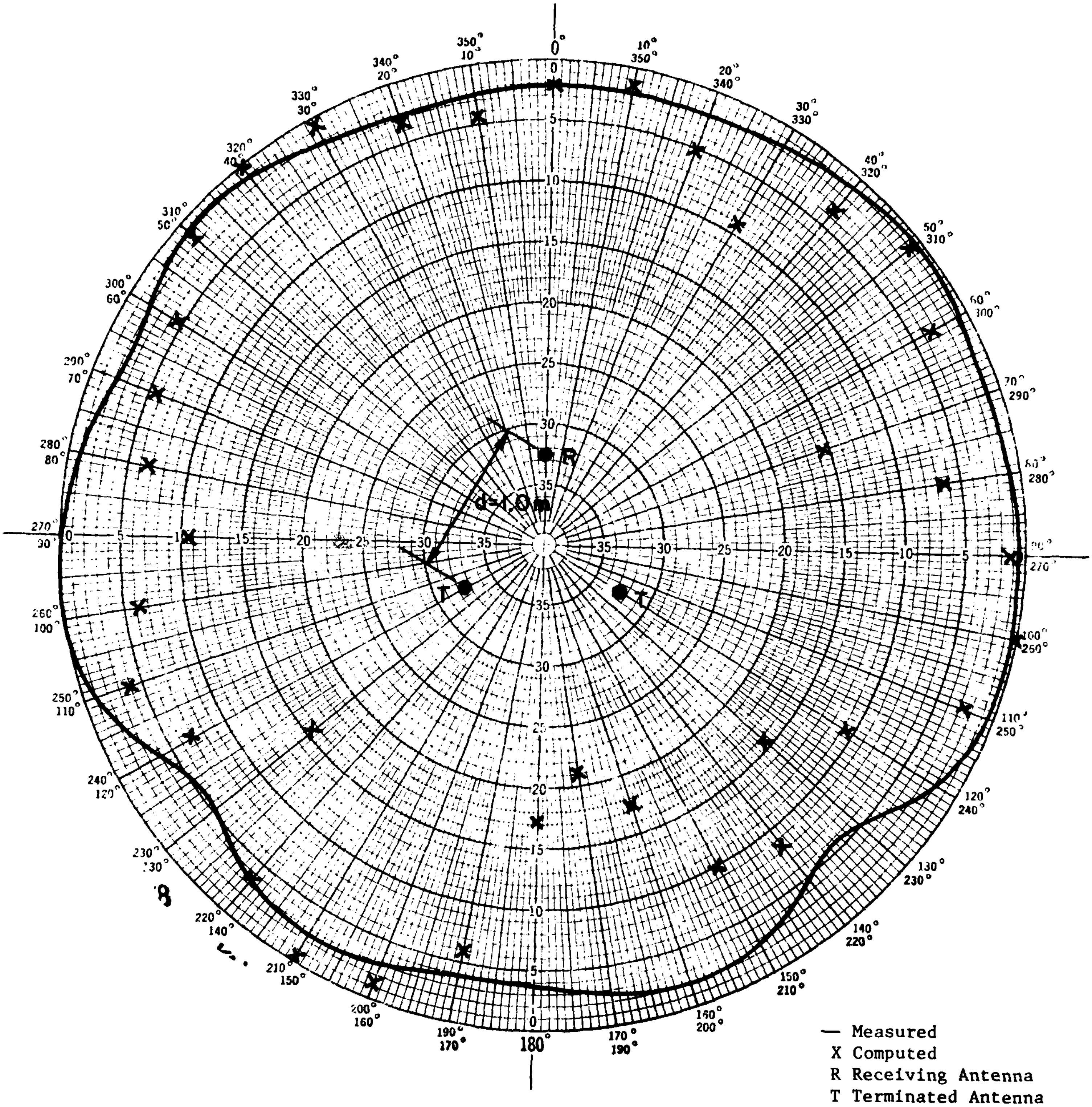
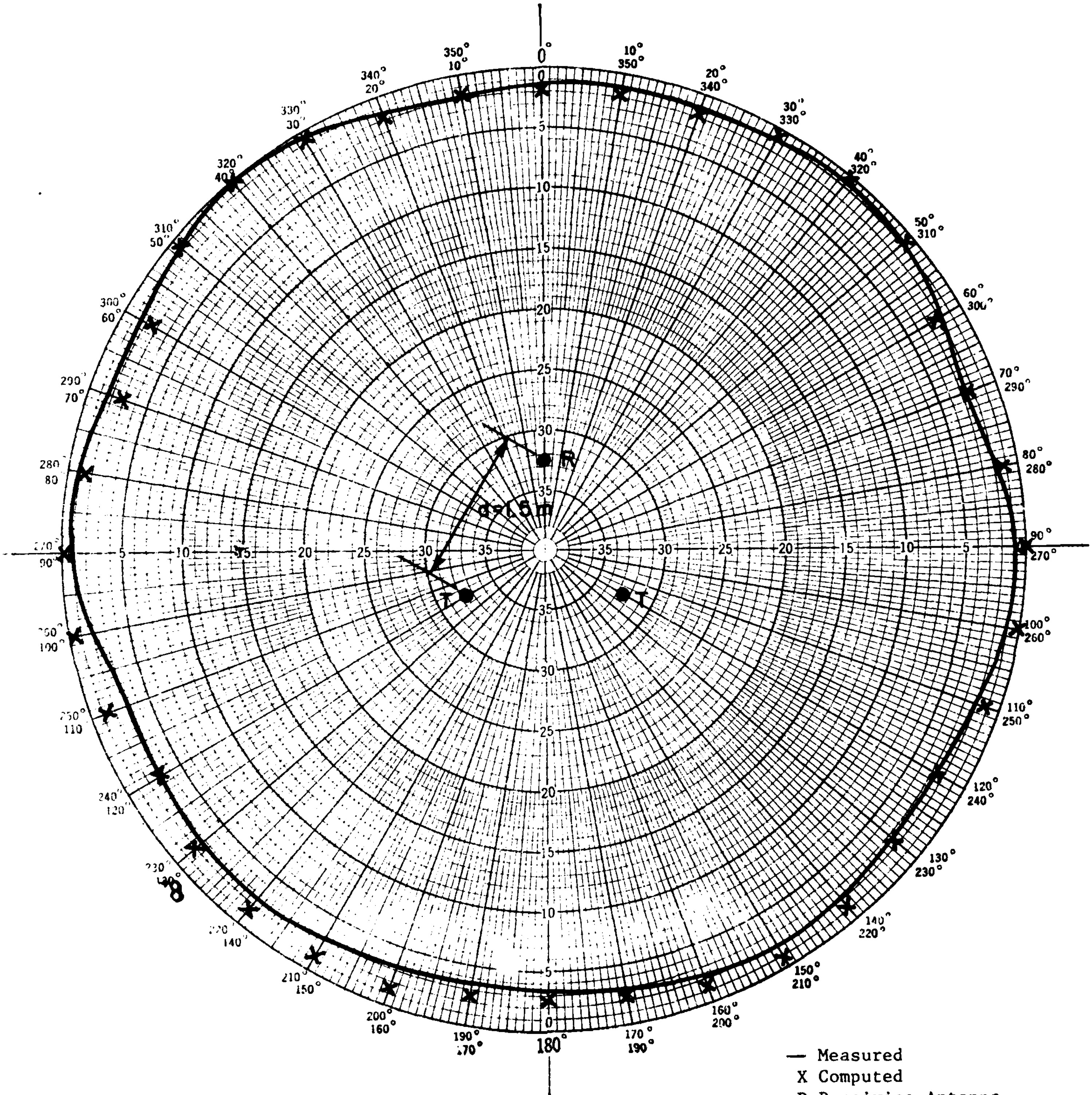


Figure 69. Three AT-197/GR, f = 400 MHz, d = 1 m, D = 8.54 m



— Measured
X Computed
R Receiving Antenna
T Terminated Antenna

Three AT-197/GR, f = 250 MHz, d = 1.5 m, D = 8.54 m

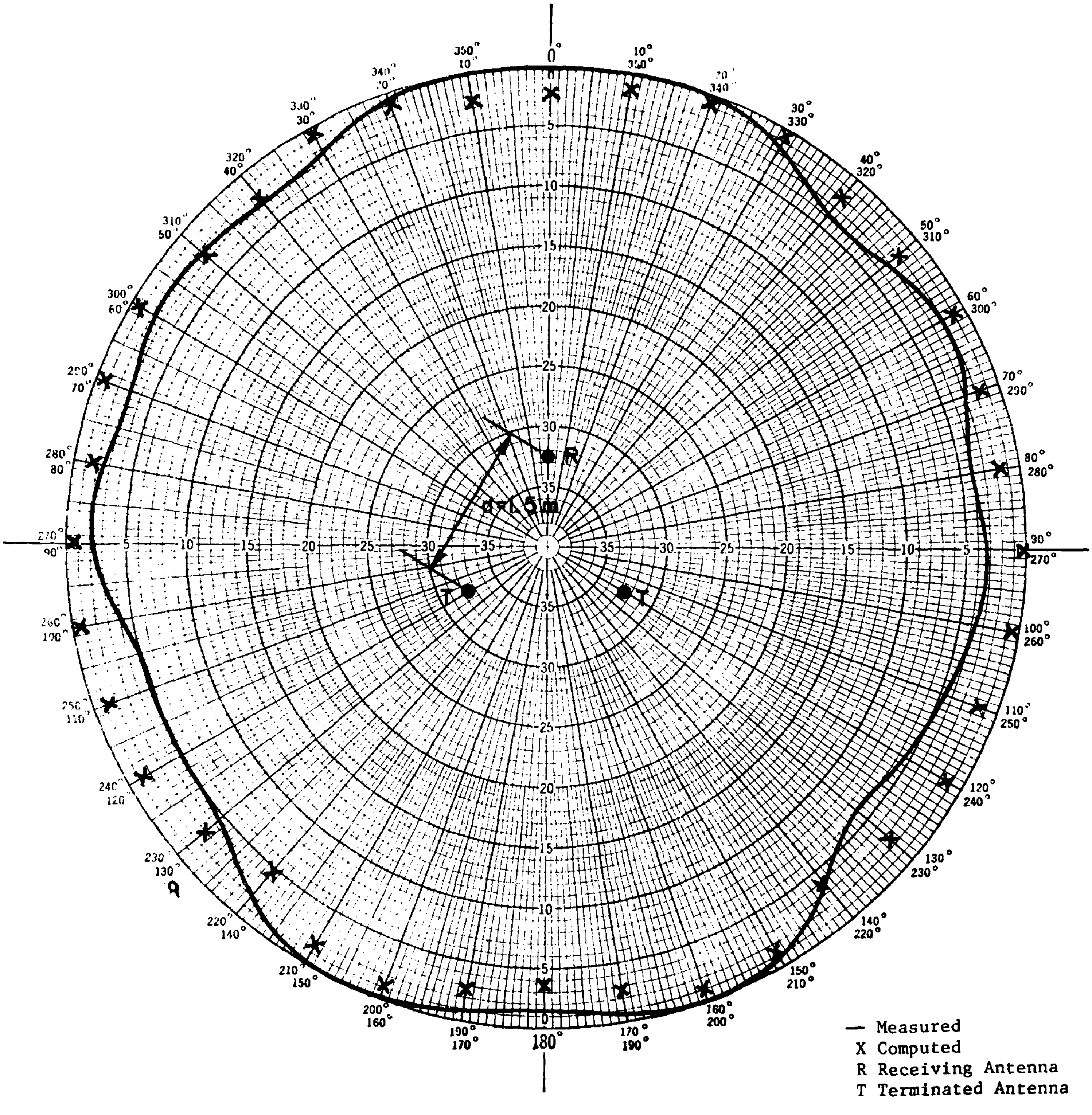


Figure 71. Three AT-197/GR, f = 325 MHz, d = 1.5 m, D = 8.54 m

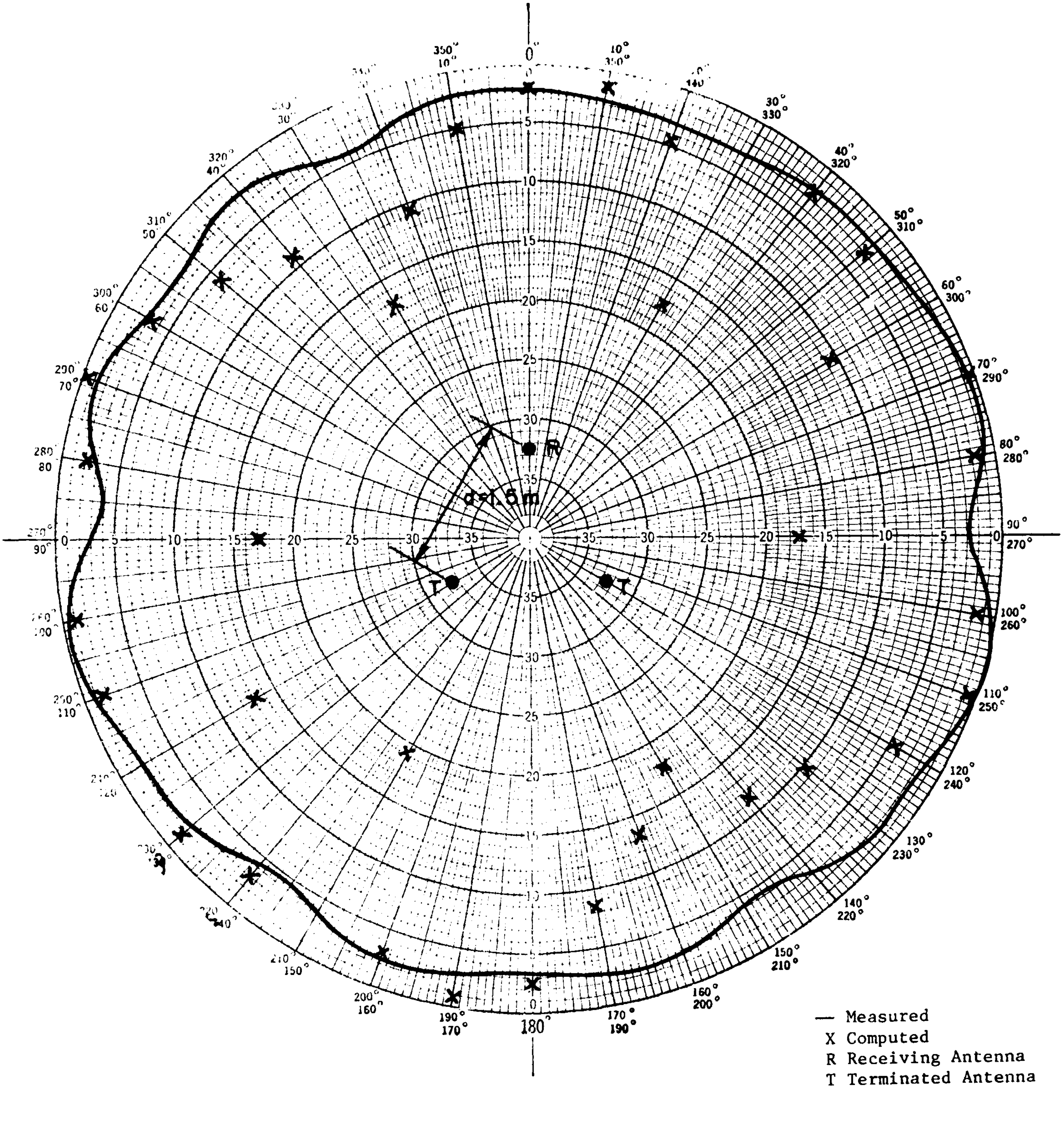


Figure 72. Three AT-197/GR, f = 400 MHz, d = 1.5 m, D = 8.54 m

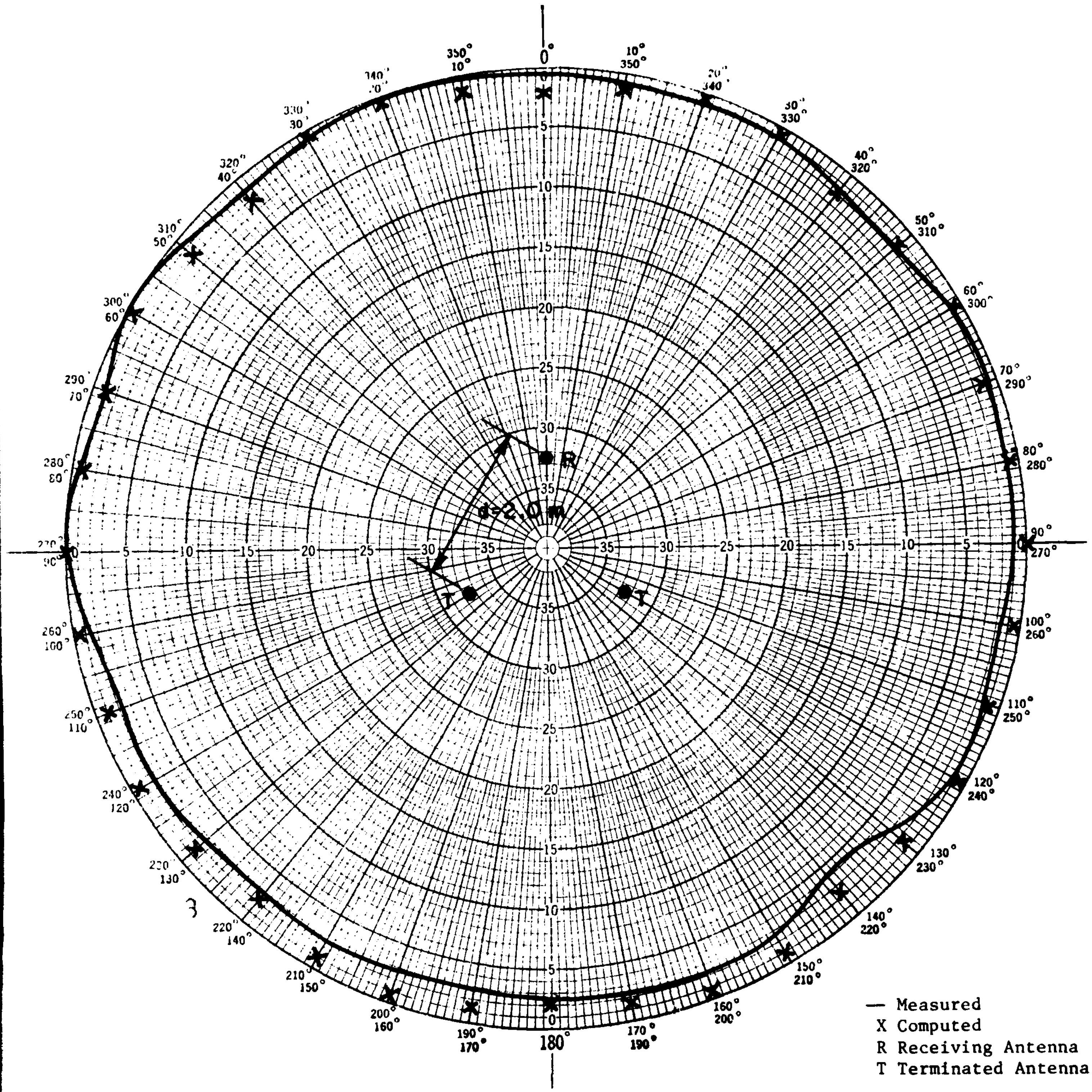
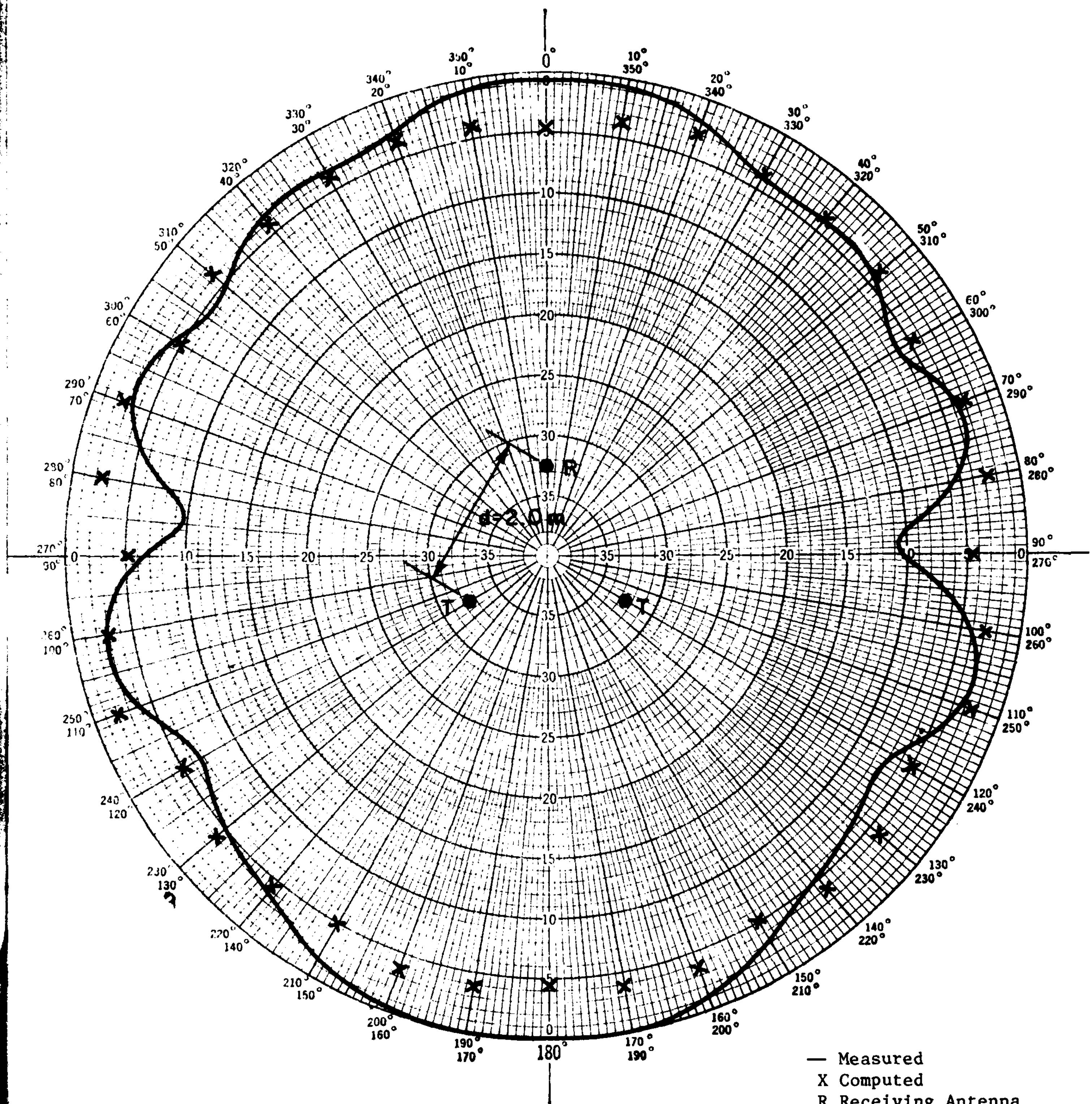


Figure 73. Three AT-197/GR, f = 250 MHz, d = 2 m, D = 8.54 m



— Measured
X Computed
R Receiving Antenna
T Terminated Antenna

Figure 74. Three AT-197/GR, f = 325 MHz, d = 2 m, D = 8.54 m

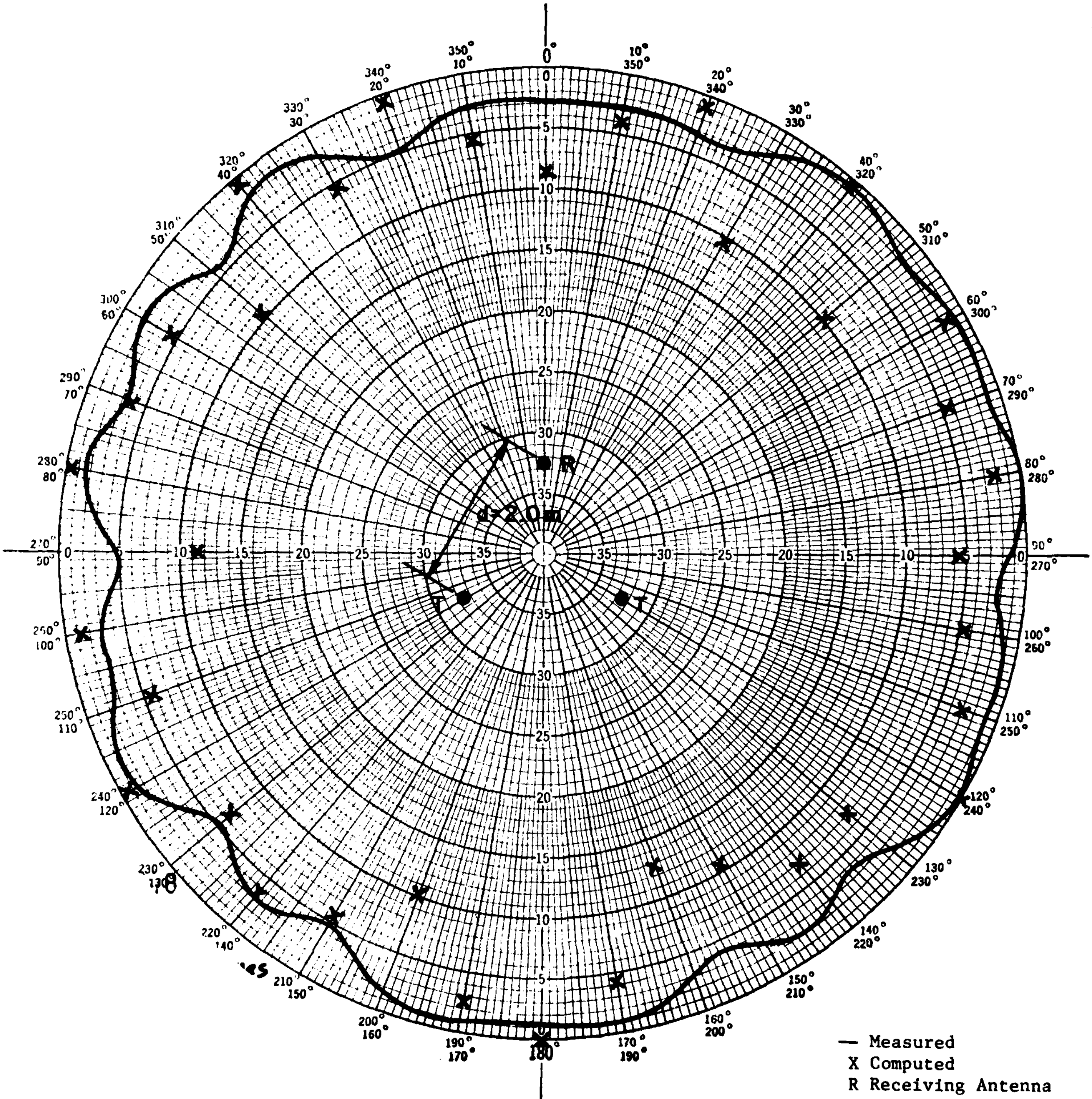


Figure 75. Three AT-197/GR, f = 400 MHz, d = 2 m, D = 8.54 m

6.4 The same observation can be made here as was the case for two AT-197/GR Antennas; the model definitely has problems at 400 MHz.

7.0 ABSOLUTE GAIN MEASUREMENTS.

7.1 For this measurement a Scientific Atlanta (S/A) standard dipole model was used. First the S/A dipole was set up and the received signal measured. The dipole was then replaced with an AT-197/GR or an AS-1097/GR and the received signal recorded. This is called the substitution method.[2] The results are shown in Table VI.

Table VI

Gain Over Standard S/A Dipole (2.15 dBi)

Frequency (MHz)	AT-197/GR	AS-1097/GR
250	-1.0	5.0
325	-1.5	2.5
350	-2.1	2.0

8.0 PROPAGATION OVER FINITE CONDUCTIVITY EARTH.

8.1 At the request of AFCC, measurements over a finite conductivity earth were performed at the Verona Test Site facility of RADC.

8.2 The purpose of the test was to verify the equations available in the literature[3] for this purpose and also to assess the performance of the AT-197/GR versus a standard dipole. As the AT-197/GR is used always at low elevation angles, the measurements were performed so that the elevation angle was less than 5°. The geometry of the measurement is shown in Figure 76. The transmitting dipole was set at heights h_t of 5, 10, 30 and 60 feet above the ground. The receiving antenna, either a standard dipole or the AT-197, was always at $h_r = 5$ feet above the ground. The distance d between the antennas was then calculated such that the evlevation angle α of the ground reflections was either 2 or 5°. The calculations for this situation are shown in Table VII.

Table VII

Calculation of d for $h_r = 5$ feet

h_t (feet)	$\alpha = 2^\circ$ d (feet)	β°	$\alpha = 5^\circ$ d (feet)	β°
5	286	0	114	0
10	430	0.67	171	1.67
30	1002	1.43	400	3.58
60	1861	1.69	793	4.23

8.3 As can be seen, the elevation angle of the direct ray varies from 0° to 1.69° for the 2° reflection angle and from 0° to 4.23° for the 5° ground reflection angle.

[3] Jordan, E.C., and Balmain, K.G., Electromagnetic Waves and Radiating Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc.

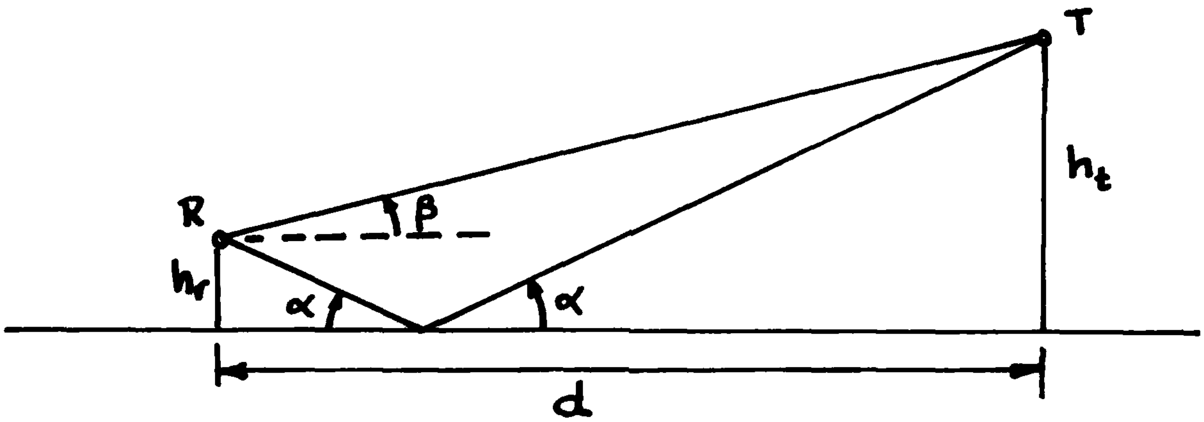


Figure 76. Geometry of Receiving and Transmitting Antennas

Table VIII

Measured and Calculated Fields of Dipoles over Lossy Terrain

h_t ft	d_t ft α^o	F MHz	$\lambda/2$ MEAS -dBm	AT-197 MEAS -dBm	$\lambda/2$ CALC -dBm	Δ $\lambda/2$	Δ AT-197
60	1861 2^o	225	46.42	47.51	47.05	0.64	-1.09
		285	46.45	45.02	47.10	0.65	1.43
		350	46.42	44.83	47.16	0.74	1.59
60	743 5^o	225	40.24	41.98	31.56	-8.68	-1.74
		285	33.01	34.34	31.88	-1.13	-1.33
		350	35.38	37.19	32.28	-3.10	-1.81
30	1002 2^o	225	42.86	43.10	42.32	-0.44	-0.24
		285	43.26	42.87	42.37	-0.89	0.39
		350	45.35	46.12	42.42	-2.93	-0.77
30	400 5^o	225	29.04	29.60	26.75	-2.29	-0.56
		285	28.29	29.31	27.02	-1.27	-1.02
		350	30.12	31.14	27.36	-2.76	-1.02
10	430 2^o	225	37.79	38.44	37.12	-0.67	-0.65
		285	37.69	38.27	37.14	-0.55	-0.58
		350	38.13	40.42	37.18	-0.95	-2.29
10	171 5^o	225	24.57	24.81	21.35	-3.22	-0.24
		285	24.26	25.09	21.51	-2.75	-0.83
		350	24.46	26.44	21.71	-2.70	-2.03
5	286 2^o	225	36.65	37.37	36.05	-0.60	-0.72
		285	36.66	37.61	36.07	-0.59	-0.95
		350	37.06	38.81	36.08	0.02	-1.75
5	114 5^o	225	20.41	20.94	20.21	-0.20	-0.53
		285	22.43	23.33	20.30	-2.13	-0.90
		350	21.81	23.80	20.42	-1.39	-1.99

8.4 Table VIII summarizes the measurement results. The frequencies used were 225, 285 and 350 MHz. After the transmitting dipole was set at its height h_t, a similar dipole (standard S/A dipole model 15-200) was set at h_r = 5 ft and the power received measured. Then the receiving dipole was replaced by the AT-197/GR and the power received measured again. These results are presented in columns $\lambda/2$ MEAS and AT-197/GR MEAS. The power transmitted was approximately 15 dBm. The numbers presented in Table VIII are all normalized for an input power in the transmitting antenna of 0 dBm.

8.5 Next, the power received by a $\lambda/2$ dipole was calculated when 0 dBm was transmitted by another $\lambda/2$ dipole placed in the identical positions used in the measurement. The results are shown in the column $\lambda/2$ CALC.

8.6 Column Δ $\lambda/2$ shows the difference between the columns $\lambda/2$ CALC and $\lambda/2$ MEAS. Therefore, a positive value means that the measured power level is higher than the calculated. The average error is -1.52 dB. An examination of Table VIII shows that the error exceeds 3 dB only at three measurements which cannot be explained except for some measurement error. If these values are excluded, the average error is -1.02 dB. Even -1.5 dB is an excellent agreement with the calculations, thus validating the accuracy of the equations used.

8.7 Column Δ AT-197 presents the difference between columns AT-197 MEAS and $\lambda/2$ MEAS. Therefore, a negative value indicates that the AT-197/GR has a smaller gain than the dipole. The overall average difference is -0.82 dB. If the average difference is computed for each frequency, then values are presented in Table IX.

Table IX

Average Gain of the AT-197/GR over a $\lambda/2$ Dipole

F (MHz)	Gain (dB)
225	-0.72
285	-0.48
350	-1.26

NOTE: This data follows somewhat the trend of Table VI.

9.0 CONCLUSIONS

9.1 From the extensive comparison of the measured and computed data for the AT-197/GR and the AS-1097/GR, it is seen that the computer model very closely represents both antennas. The deviations between measured and computed data are usually within the predicted mesurement error due to reflections in the Anechoic Chamber. The only exceptions to this are the 400 MHz runs for the AT-197/GRs where the errors are greater than expected. This may be caused by the number of subsections that were used in the antenna model and is an easy problem to correct now that we have measured data to compare with.

9.2 From the measurements of the antennas over finite conductivity ground, as reported in Section 8, we also may conclude that the theoretical model predicts quite well the actual received fields.

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